MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY.

Publication 8
Geological Series 6

Mineral Resources of Michigan with Statistical Tables of production and value of mineral products for 1910 and prior years

PREPARED UNDER THE DIRECTION OF

R. C. ALLEN

DIRECTOR, MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

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LETTER OF TRANSMITTAL.

To the Honorable, the Board of Geological and Biological Survey of the State of Michigan:

Gov. Chase S. Osborn, President.
Hon. D. M. Ferry, Jr., Vice President.
Hon. L. L. Wright, Secretary.

Gentlemen:—Under authority of act number seven, Public Acts of Michigan, Session of 1911, transferring to the Board of Geological Survey the duties which formerly devolved on the Commissioner of Mineral Statistics as defined by Act number nine of the Public Acts of 1877, I have the honor to present herewith Publication 8, Geological Series 6, a volume on the Mineral Resources of Michigan containing statistics of production and value of mineral products for 1911 and prior years with outline of the present status and progress of the more important mineral industries of the state.

Very respectfully,
R. C. ALLEN,
Director.

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INTRODUCTION.

In this volume there is presented a general survey of the more important mineral industries of the state together with statistical data of production and value of the mineral products in 1911 and prior years.

Under a coöperative agreement with the U. S. Geological Survey, reports of production and value of mineral products and other items of information have been received directly from the producers except in the case of copper and pig iron. We take this occasion to express our thanks and appreciation to all who have thus contributed to this volume. The information received in this way is properly tabulated and kept on file in the Survey office. Statistics of production are published in such detail as is permitted by space at command with due regard to the interests of the various producers. Information, other than purely statistical material, which is received in confidence is not disclosed. Those reports of individual production which are not a matter of public record are tabulated in state, county or district totals.

The labor involved in the preparation of this volume has devolved on various members of the Survey and some special appointees, each of whom has some special familiarity with the subjects presented by him. A part of the information has been obtained by personal work in the field, a second part by correspondence and reports from the producers and a third by reference to the literature. In preparation of the articles on the copper and iron industries we have had special reference to two recent publications viz., "The Appraisal of the Mining Properties of Michigan" by J. R. Finlay and Monograph 52, U. S. Geological Survey by C. R. Van Hise and C. K. Leith. The former contains a closer estimate of reserves of copper and iron ores than heretofore attempted and the latter, accurate statistical and geologic data, especially of the iron districts, and complete revised maps of the mineral producing areas.

Copper. The main features of Mr. Hore's article on the Copper industry are the description of the copper lodes, a thing not heretofore attempted in such completeness of detail, and a review of recent developments in copper mining and exploration. Unlike the iron mining industry the copper industry is a quasi-public enterprise, financed by a very large number of stockholders in Michigan and other states. For this reason the description of particular properties and details regarding the various companies should be useful to a large number of people.

Iron. The inclusion of deails regarding the various iron mines and iron mining companies is omitted for a number of reasons among which are: lack of space; such details have been published in recent reports of the Lake Superior Institute of Mining Engineers;. the general public is not interested in these details to the same extent as in the case of the copper companies; the desire to include more complete statistical data and a general account of the more important factors in the iron mining business.

The important recent developments on the different ranges have been noticed, particularly the bearing of these on the future of the iron mining industry, and special stress laid on developments of new properties and the extension of producing ground in the Iron River and Crystal Falls districts lying in the great Upper Huronian slate area containing probably the greatest undeveloped ore reserves of the state.

As bearing on the problem of the utilization of low grade ores, there is presented a special article by Mr. Albert E. White on the Jones Step Process, the first authoritative description of the experiments which are being conducted by Mr. John T. Jones of Iron Mountain and associates.

The status of the pig iron industry was made the object of a special investigation by Mr. White and is a valuable contribution to the literature of iron making in Michigan.

Coal and Gypsum. The Survey reports on coal and gypsum have been out of print for a number of years and, therefore, there has been given to these subjects more space than would otherwise have been done.

Oil and Gas. Drilling for oil and gas is somewhere in the state going on almost continuously. On no other subject does the Survey receive so many demands for information. In the article on oil and gas Mr. R. A. Smith presents the available information and the article is commended to all persons contemplating exploratory operations. Reports from drill men on indications of oil or gas and accurate well records, are earnestly solicited that the Survey may better keep in touch with the situation as it develops. Scattered bits of information of no significance when considered singly may when correlated have an important bearing on the matter of intelligently directed exploration.

Salt and Cement. Mr. C. W. Cook has made special studies on these subjects. The article on salt is partially a brief abstract of an extended treatise on this subject which Mr. Cook has had in course of preparation for the Survey for the past eighteen months and which will appear in print it is hoped before the end of the year. The basis of the report on cement is the information obtained by Mr. Cook in 1911 for the State Tax Commission under the direction of Mr. J. R. Finlay.

Miscellaneous Products: Lack of space in this volume precludes the inclusion of descriptive matter bearing on the minor mineral products. There is given, however, statistics of production and value for 1910 and 1911. Special reports on particular mineral industries will appear in subsequent volumes but all of them cannot be thus treated each year.

List of the Mineral Producers of Michigan. There is included a directory of the mineral producers of the state. There are doubtless some omissions in the list but it is complete so far as we have data. Its publication should aid dealers, miners, manufacturers and others interested in the mineral industry in getting in touch with each other. The Director will appreciate the receipt from any source of additions or corrections to the directory.

TO THE MINERAL PRODUCERS OF MICHIGAN.

The Survey invites criticism of this and subsequent annual statements of similar character. If you find inaccuracies of statement, let us know of them; if you can suggest an improvement, kindly do so. We want your coöperation in making the annual statement of development and progress in the mineral industry of maximum usefulness. A State Geological Survey should function in part as a bureau of natural resources; we hope that you will use the Michigan Geological Survey as such. If you want information that does not appear in our formal reports, write for it; the probabilities are that we have it if it exists or if we cannot give it to you we can direct you to sources where it may be obtained. Our information is public property with the exception of certain matters which are considered as a private business asset by the sources from whence it comes to us.

R. C. ALLEN,
Director.

Lansing, Michigan, February 15, 1912.

THE COPPER INDUSTRY OF MICHIGAN.

BY

REGINALD E. HORE.

PREFACE.

In the following pages will be found some account of Michigan's copper deposits and mines. In preparing this I have drawn on the writings of many authorities and desire to mention those I have consulted most frequently.

For geological descriptions I have made free use of the writings of Pumpelly,[1] Irving,[2] Hubbard,[3] Lane,[4] Seaman,[5] Wadsworth,[6] Wright,[7] Rickard,[8] and Gordon.[9]

For mine descriptions and company notes, the Copper Handbook published annually by Horace J. Stevens of Houghton, has proven of great assistance. Those who are intimately acquainted with the copper industry, know Stevens' Handbook to be carefully written and based upon information from reliable sources. It contains descriptions of the property of every copper mining company that operates or has operated in Michigan, and includes information on a number of subjects which are not mentioned at all in my report. I wish to acknowledge my indebtedness to Mr. Stevens, and to recommend the book to others.

For statistical data I have used especially the figures collected and published by the U. S. Geological Survey and the State Commissioners of Mineral Statistics; but I have also used figures published in Stevens' Handbook and in J. R. Finlay's report to the State Tax Commissioners. For individual mines I have accepted the

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[1]Copper-Bearing Rocks of the Upper Peninsula, Raphael Pumpelly. Geol. Sur. Mich., Vol. I, 1873.

[2]The Copper-Bearing Rocks of Lake Superior, by R. D. Irving. U. S. G. S., Monograph V, 1883.

[3]Keweenaw Point, by L. L. Hubbard. Geol. Sur. Mich., Vol. VI, 1898.

[4]The Geology of Keweenaw Point—a brief description. A. C. Lane. Pro. L. S. Min. Inst., 1906, pp. 81-104.

[5]Notes on the Geological Section of Michigan. A. C. Lane and A. E. Seaman. Jour. Geol., Vol. XV, No. 7, 1907.

Native Copper Deposits, A. C. Lane. Quebec Meeting Canadian Mining Institute, 1911.

[6]Origin and Mode of Occurrence of Lake Superior Copper Deposits. M. E. Wadsworth. A. I. M. E., Vol. XXVII, pp. 669-696, 1898.

[7]The Intrusive Rocks of Mt. Bohemia. F. E. Wright. Mich. Geol. Survey, Sept., 1908, pp. 355-402, 1909.

[8]Copper Mines of Lake Superior. T. A. Rickard.

[9]A geological section from Bessemer down Black River. Mich. Geol. Survey, 1906, 99. pp. 399-507, 1907.

figures contained in the annual reports of the mining companies. Some figures have been specially collected from the companies for this report.

For a general description of the mines and the methods of mining, I would recommend T. A. Rickard's book on Copper Mines of Lake Superior, and a series of articles[10] by R. B. Brinsmade. Methods in use at individual mines and mills have been described by a number of writers in various publications, and references to some of these will be found in the footnotes. Mr. A. Carnahan[11] has published interesting accounts of the two largest properties.

Accounts of the early development of the copper district will be found in H. Steven's handbooks and in articles by H. V. Winchell and Graham Pope published by the L. S. M. I., in 1894, Vol. II, pp. 33-50 and 1901, Vol. VII, pp. 17-31.

To readers interested in a thorough discussion of the geology, I wish to recommend Dr. A. C. Lane's Monograph,[12] now being printed for the State Survey. A briefer account of the general geology and a discussion of the origin of the ores by Van Hise, Leith and Steidtman has been recently published by the U. S. Geological Survey, as part of a monograph[13] on Lake Superior geology. Both these reports are accompanied by numerous geological maps.

An excellent map showing company holdings has been published by R. M. Edwards, and recently revised by B. F. Sparks and W. R. Hodge of Houghton.

REGINALD E. HORE.

Houghton, Mich., January 10, 1912.

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[10] Michigan Copper Mines and Methods. Min. World, 1910, Mar. 12, Mar. 26.
[11] Calumet and Hecla. Min. World, Oct. 13, 1906.
Copper Range Consolidated. Min. World, Dec. 1, 1906.
[12] The Keweenaw Series of Michigan. By Alfred C. Lane. M. G. S. In press.
[13] Geology of the Lake Superior District. By Chas. Van Hise and C. K. Leith. Mono. 52. U. S. Geol. Surv. 1911.

CONTENTS.

CHAPTER I.

INTRODUCTION.

Location of the Mines. The Copper Mines of Michigan are all located on Keweenaw Point, the prominent peninsula which extends for seventy miles northeasterly from the south shore out towards the middle of Lake Superior. As may be seen from the accompanying map, the mines are in the counties Ontonagon, Houghton and Keweenaw. In the early days the chief activity was in the vicinity of the Mass and Minesota mines in Ontonagon county, and in the Eagle River section of Keweenaw county, but in recent years nearly the whole production (86.2% in 1910) has come from mines in Houghton county. Most of the producing mines are in a 25 mile section of the copper range between Painesdale and Mohawk. In order from southwest to northeast are the following important mines: Champion, Trimountain, Baltic, Atlantic, Superior, Isle Royale, Hancock, Quincy, Franklin, Osceola, Calumet and Hecla, Tamarack, Centennial, South Kearsarge, Wolverine, North Kearsarge, Allouez, Ahmeek, Mohawk and Ojibway. All but the last four are in Houghton county, and these are in Keweenaw county. Further southwest in Ontonagon county, are the Lake, Mass, Adventure, Michigan and Victoria mines. Other active properties in

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[1]For diagram by Prof.
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[2]Fault in Central Mine. Mich. Geol. Sur., Vol. VI., 1896. pp. 86-91.

The Copper-bearing rocks. The Keweenaw formation in Michigan is commonly divided into two[3] series, lower and upper. The lower is largely igneous, with occasional interstratified beds of sediment, and the upper largely sedimentery with some interbedded layers of igneous rocks. The copper bearing lodes are, with one exception, in the lower Keweenawan. The exception is a deposit in sandstone in the upper series.

The Lower Keweenawan of the Copper Range is chiefly made up of dark grey and brownish volcanic rocks in beds usually between 10 feet and 200 feet in thickness; but often thinner or thicker. With the dark colored volcanic rocks are imbedded reddish conglomerates and sandstones, ranging from mere seams up to beds of several hundred feet in thickness. In the horizon of the chief productive lodes, the sediments form only about 7 per cent of the total thickness of the formation. In addition to the dark colored volcanic rocks, there are much smaller areas of light colored felsitic and porphyritic types, and more basic coarse grained intrusive masses. The felsites do not occur in the immediate vicinity of the chief copper lodes; but are common at both lower and higher horizons. Distinctly grained intrusive rocks, such as gabbros, occur in the Keweenaw series but are not found in the copper mines.

The dark colored heavy volcanic rocks* range in composition from basic to intermediate, while those of lower specific gravity and light color are more highly siliceous. Dark colored dense effusives are commonly called *trap* and are mostly *melaphyres* or *porphyrites*, the former basic and the latter of intermediate composition. These are often partially amygdaloidal, and such portions are commonly designated simply as amygdaloids. The melaphyres are from their different textures classed as *diabases, ophites* and *dolerites*. Diabases show lathshaped feldspars enwrapped by augite, while ophites show lustre mottling on pyroxenes, and dolerities are even grained and lack the diabasic texture and lustre mottling. The light colored rocks are called *felsites* and *porphyry*. The felsites are composed chiefly of a fine felted mass of feldspar and quartz, and in some varieties have phenocrysts of feldspar. The typical porphyries show phenocrysts of quartz, and occasionally of feldspar, in a very dense ground mass, usually quite light colored and sometimes brownish red.

[3]A third division is sometimes, and notably in a recently published monograph by C. R. Van Hise and C. K. Leith of the U. S. G. S., made to include only the sediments found in some localities at the bottom of what is more commonly called the Lower Keweenawan. The rest of the Lower is then called Middle Keweenawan.

*Numerous descriptions of the melaphyres will be found in A. C. Lane's report on Isle Royale. The felsites of Keweenaw Point have been described by L. L. Hubbard in the report of the Geological Survey for 1898.

Alteration of the rocks. Almost all the Keweenawan rocks are much altered. Many have been almost completely changed by the development of new minerals. The melaphyres are usually of dull brownish or greenish color, due to secondary products, common colored ones being chlorite, epidote and a brown micaceous mineral resembling iddingsite. Very commonly a considerable portion of a bed below the true amygdaloid top is spotted with aggregates of chlorite and other secondary minerals, so that it resembles amygdaloid and is called *pseudamygdaloid.* The felsites usually show a devitrified ground mass, in which are abundant particles of secondary quartz and altered feldspars, while here and there are areas of calcite and epidote. The coarse grained intrusive rocks, such as gabbro, have commonly an abundance of chlorite or secondary hornblende from the alteration of the original ferromagnesian minerals. The two green colored secondary minerals, chlorite and epidote, are very abundant in the copper bearing rocks.

The sedimentary beds are chiefly coarse red *conglomerates*, red-brown and grey *sandstones* and grey or brown *shales*. The pebbles in the conglomerates are mostly reddish or brownish felsites, and in one locality quartz porphyry. The sandstones and the matrix of the conglomerates are very largely made up of small particles of rock as well as of mineral fragments. Many of the sediments have evidently been largely, if not wholly, derived from the igneous beds of the Keweenawan series itself. The upper Keweenawan is composed of thick beds of conglomerates, sandstone and shale, with comparatively few igneous beds.

CHAPTER II.

MODE OF OCCURRENCE OF THE COPPER.

Practically all the copper mined occurs as the native metal. Arsenides and sulphides are found in some small veins, but the tonnage mined is very small. One lode, the extent of which is not yet known, has copper in the form of oxide, silicate and carbonate minerals.

The native copper occurs chiefly in bedded deposits. It fills cavities and replaces mineral and rock constituents of conglomerates and amygdaloids. By far the richest lode is a conglomerate, but all the others now being worked are amygdaloids. Other types of deposits are fissure veins cutting across the formation, epidotic beds parallel or nearly parallel the formation and disseminated copper in sandstone. Recently copper has been found in a much altered and fissured mass of felsite.

The bedded deposits are long and continue to great depths. The most important ones are worked for a distance of two to five miles along the strike. Two of the lodes are still being worked at over a mile down on the slope of the beds, and it is probable that others will be worked to a like depth. Most of the lodes average over ten feet in thickness, and some over twenty.

Conglomerate lodes. In the conglomerate lodes the copper occurs chiefly in the matrix, and has irregular branching forms suggesting that it has filled cavities in the porous rock. In other cases, however, there is copper in forms which show that it has taken the place of other constituents in the rock, and in many cases it has partially replaced large pebbles.

Amygdaloid lodes. In the amygdaloid lodes the copper occurs partly with other minerals, filling the amygdules. Much of it, however, is not in the form of a filling. As a rule the rock carrying high values in copper is to a large extent made up of secondary minerals, and the metal is usually enclosed in masses of these, especially in calcite, epidote, chlorite, prehnite and quartz. The copper, like these and other secondary minerals, is in such cases evidently a replacement deposit.

Fissure veins. In fissure veins the native copper occurs in masses, very irregularly distributed. The most usual immediate associates of copper are epidote, prehnite and chlorite. Calcite is abundant in most veins, but calcite veins not showing these silicate minerals seldom show copper. The veins worked were narrow in the traps, but widened out where the fissure crossed more porous strata. Commonly there are numerous masses of country rock enclosed in these veins, all of which cut across the formation and are nearly vertical. None are now being worked, but a large quantity of metal was taken from such deposits at the Cliff and Central[1] Mines years ago.

Epidotic beds. Epidotic beds, yellowish green in color, and composed largely of epidote and quartz, are frequently found, and several contain disseminated copper. In only one mine, however, has an important tonnage been taken from deposits of this sort. At the Minesota Mine an epidote bed striking with the bedded traps, and dipping nearly parallel with them, yielded a number of exceptionally large masses of copper and made the mine a dividend producer for a few years.

Deposits in sandstone. Sandstone and conglomerate carrying particles of copper occur in the upper Keweenawan in a horizon far above that of any of the important lodes. The copper fills in the spaces between sand grains, and is in very small particles. It is sometimes in mere films, but most of it is in grains.

Deposit in felsite. Native copper has been found at the Indiana and adjoining properties in Ontonagon County in a type of rock that has not been found productive elsewhere in Michigan. The copper occurs with secondary quartz, calcite and epidote in a felsite that is badly decomposed and full of joints and calcite seams. The felsite has been much crushed, and in places is brecciated. The natural deduction, from examination of the drill cores, is that the copper has been deposited with the calcite and other secondary minerals in much the same way as in the other lodes.

Arsenides in veins. Arsenides and sulphides are found in some of the mines in veins a few inches wide cutting across the lodes.

The arsenides are of variable composition containing copper, arsenic, cobalt and nickel in many different proportions. Names have been given to several varieties, including keweenawite $(Cu, Ni)_2 As$, mohawkite, whitneyite, (Cu_9As) domeykite, (Cu_3As) algodonite (Cu_6As). The usual gangue mineral in fissures is calcite. The veins often show calcite as the earliest deposit forming against the walls, while the arsenides fill the central portion, the resulting appearance of a vein in the dark traps is that of a white band with a dark streak down the middle.

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[1]Diagrams of the vein at the Central mine are given in a paper by L. L. Hubbard in proceedings of the Lake Superior Mining Institute, Vol. 3, 1895; pp. 74-83.
[2]The crystal character of the arsenides have been studied and described by Dr. Koenig. L. S. Min. Inst., Vol. 7, pp. 62-64.

Sulphides in veins. Sulphides are found in veins similar to those containing arsenides, but are of even less commercial importance. The veins are very narrow, generally less than one inch wide. Chalcocite (Cu_2S) is the most common sulphide. Covellite (CuS), Bornite (Cu_3FeS_3), and Chalcopyrite ($CuFeS_2$) also occur.

Copper oxide, silicate and carbonate. A deposit of copper oxide, silicate and carbonate minerals has recently been opened up in an amygdaloid bed at the Algomah Mine. It shows black melaconite (CuO), green chrysocolla ($CuSiO_3+2H_2O$) and green malachite ($CuCO_3.\ Cu(OH)_2$) in irregular masses, and also as minute veinlets, filling the crevices in a brown melaphyre. The deposit follows the bedding of the rocks, making bodies of varying thickness along the strike. Chrysocolla in felsite has been found in drill cores from other properties in the neighborhood.

CHAPTER III.

THE ORE DEPOSITS.

A large number of lodes are being worked. The most important producing lodes are the Calumet conglomerate and the Kearsarge, Baltic, Pewabic, Osceola and Isle Royale amygdaloids.

The Calumet lode is the cupriferous portion of one of the conglomerate beds in the lower Keweenawan series. This bed continues for a distance of several miles, but the ore bearing portion is confined to that part, about two miles long, which outcrops on the property of the Calumet and Hecla Mining Company, and which at depth crosses into the property of the Tamarack Mining Company. On other properties north and south, development of the conglomerate has not proven profitable. The best ore[1] was in two shoots at Calumet and South Hecla shafts pitching north at about 70°.

The conglomerate rock mined is made up largely of pebbles of felsites and quartz porphyries cemented together with small particles or rock, calcite and native copper. The cementing material contains also, in smaller amounts, other minerals such as iron oxides, quartz, epidote and chlorite. There are a few pebbles of melaphyres, amygdaloids and porphyrites.

The conglomerate is characteristically red, both pebbles and the cement being commonly of that color. Most of the constituents are of light tones; but a considerable portion is made up of pebbles that are dark reddish brown. Most of the lighter colored pebbles, light red or flesh colored, are dense felsites and quartz porphyries. The darker colored ones have usually a finely felsitic ground mass with phenocrysts of brown red feldspar. Other dark brown ones have a very dense ground mass with phenocrysts of quartz. Some are dark colored felsitic rocks with no phenocrysts. Many of the pebbles show an outer rim of lighter color than the interior. This results from alteration.

The small rock particles in the matrix are similar in character to the pebbles, but have been more extensively altered. The copper occurs chiefly as part of the cement, filling spaces between sand grains and pebbles, but some has replaced the rock constituents.

[1] P. Kirchoff, Eng. & Min. Jour., July 12, 1884, pp. 17-20.

It is a common occurrence to find large pebbles partially replaced by native copper,[1] and at some rock houses a number of these are picked out every day. While most of the copper is coarse, much is in very minute particles and the ore has to be finely ground to permit of its recovery.

When a large section across the lode is exposed, as in the drifts and stopes, there are usually to be seen rather distinct light and darker colored portions. The copper is chiefly in the light colored portions. The darker colored places are noticably more compact and less altered than the lighter. They heve evidently not been much influenced by the solutions which is more porous parts altered the rock and deposited native copper.

The thickness of the lode, as determined by mining operations, is from ten to twenty feet. There are some thicker and thinner parts. Near the surface at the Calumet Mine the lode is about thirteen feet, at some levels at great depths at the Tamarack Mine about twenty-two feet, and at similar depth further south in the Hecla mine only about ten feet thick. The average thickness of the ore still to be mined is said to be about 15 feet. The thickness sometimes varies considerably in short distances. According to Capt. Daniell, the thin portions "seems to occur in spots rather than in regular courses." As a rule the values are irregularly distributed from wall to wall. In places the poorest part of the lode is near the hanging wall, and there are places where the upper portion is the richest. In extensive workings tributary to one deep shaft the portion next the footwall was always the least productive.

At the Calumet mine the lode strikes N 33° E and near surface dips to the N. W. at an angle of about 38°. At the South Hecla mine the dip at surface is 39°. At depth the angle of inclination is slightly less than at surface. One shaft, following the lode closely, is inclined at 38° down to the 36th level, and below that at 37° 30′.

The copper content of the conglomerate in the upper levels averaged 2% to 5% for a large output. In 1888, when the C. & H. mine was about 3,000 feet deep the ore mined yielded 4.5% copper. In 1900 the ore mined averaged 3% copper; but the working below the 57th level in the northern part of the mine have yielded ore of much lower grade. The average for the Calumet and Hecla mine for 1910 was 30.12 pounds per ton, while the output of the Tamarack mine in the same year averaged 21.1 pounds copper per ton of ore.

[1]See Dr. A. C. Lane's paper, "A boulder from the Calumet conglomerate." Econ. Geol., Vol. 4, and pp. 158-173, 1909.

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[1]See Dr.
Geol., Vol.

In the mines blocks found to be low grade are left standing but aside from this there is little selection of the ore. Practically all the conglomerate broken in the stopes is hoisted and stamped.

The conglomerate lode has yielded more copper than any other on Keweenaw Point, and the metal has been won at a cost which has made the Calumet and Hecla the leading dividend producer among the mines of the world. The Tamarack mine has also a good record.

Mr. J. R. Finlay estimates that the C. & H. has still on the conglomerate lode about 27,000,000 tons of ore, which should yield 26 pounds per ton—a total of 702,000,000 pounds copper. Another estimate is 30,000,000 tons, 900,000,000 pounds. On account of great depth and lower values, the Tamarack portion of the lode gives little or no profit at present prices of copper.

The Kearsarge Lode is the copper-bearing amygdaloidal upper portion of a bed of porphyritic melaphyre. The melaphyre near the lode is a dark grey or brownish ophite, with large phenocrysts of feldspar, usually greenish labradorite. The lode itself is commonly a brownish amygdaloid, with numerous and large amygdules of calcite, quartz, red feldspar and green epidote. Some copper occurs filling amygdules; but much of it is in irregularly shaped forms, which have evidently replaced the rock. Much of the copper is closely and probably genetically associated with epidote.

At Calumet the Kearsarge amygdaloid lies about parallel to the Calumet lode, having a strike N 33° E and a dip to the northwest of 38°. Further north the lode curves off more to the east.

The lode is several miles in length, and is being mined for a continuous stretch of five miles at the Centennial, South Kearsarge, Wolverine, North Kearsarge, Allouez, Ahmeek and Mohawk Mines. Further north it has been opened up on the Gratiot, Seneca and Ojibway properties, and the latter, four miles northeast of the Mohawk, has since Nov. 1, 1911, been making shipments for a mill test. Further south the lode has been opened up on the Calumet and Hecla, Laurium, Osceola and LaSalle lands, but though copper has here also been found in the lode, no large body has proven enough to be mined profitably at present.

The ore mined on the five mile stretch from Centennial to Mohawk yields from 13 to 25 pounds copper per ton. The richest portions are at the Ahmeek, where the 1910 average was 22.3 pounds, and at the Wolverine, where the average for the fiscal year 1910-1911 was 24.75 pounds refined copper per ton of ore stamped. At the Wolverine the ore is unusually uniform in grade and the percentage of rock broken and not stamped is very small.

Mr. Finlay estimates that the five leading mines on the Kearsarge lode will produce 63,600,000 tons of ore, yielding 986,000,000 pounds of refined copper.

The Baltic lode is the upper portion of a melaphyre low down in the Keweenawan series. The amygdaloid has commonly grey or brownish groundmass, and amygdules of white calcite. The denser part of the bed, the footwall trap, is a brown melaphyre with abundant spots of green chlorite. The minable copper is not confined to the amygdaloid, and frequently makes well down into the trap, thus making the lode very wide in places. Narrow veins carrying sulphides and arsenides are found in the lode, but are of no consequence as ore.

At the Baltic Mine the lode strikes N. 60° E. and dips 73° N. W. The dip is much steeper than that on any of the other lodes, and consequently the method of mining is different, and will be described later.

The width varies commonly from 15 ft. to 60 ft. In some places the lode is mined for a width of 80 or 90 ft. The thickness is in most places greater than 20 ft. and averages about 24 ft.

Fissures are numerous in the lode, and at some of the mines faults and soft seams cut across it at short intervals. Many of the fissures are filled with calcite, which make conspicuous, though usually very narrow, white veins, running across the dark rock. Many others are filled with soft greenish and reddish material, chloritic, talcose or clayey. These soft seams have apparently resulted from crushing and slipping. Often in such ground, the lode is displaced many times in a short distance.

The main production of the Baltic lode is from a three mile stretch worked at the Champion, Baltic and Trimountain mines. Further northeast operations on the Baltic lode have opened up only one important ore body—that at the Superior Mine. At the Atlantic section 16 shaft the lode was found very badly fractured, faulted and crushed, and there was great difficulty in identifying horizons. The ore bodies found were cut off by faults at short distances, and the workings were generally in poor rock. After a thorough exploration the shaft was recently abandoned. At the Superior Mine the lode is also much fractured, but a large body of good ore has been blocked out at one shaft. Further north recent exploration work by the Houghton Copper Company has shown the extension of the lode. As at the Superior, the rocks are here much fractured and full of slips. Similar ground was found in exploration on the Isle Royale property, which the Houghton adjoins.

evidently replaced the rock, and forms irregularly defined

At the Champion, Trimountain and Baltic Mines, the lode is comparatively firm. There are numerous fissures, but the ground has not been so severely disturbed as further northeast. In some places at the Trimountain and Baltic Mines the lode is more broken up. Between the Trimountain and Baltic mines there is a marked change in strike of the lode and possibly considerable faulting.

In all the mines on the Baltic lode, the system adopted is to break the rock for the full width and sort out the poor rock and use it to fill in the stopes. The sorted ore from the different mines in 1910 yielded 17.95 to 26.6 pounds copper per ton. At the Superior Mine much of the copper is unusually fine, and so disseminated that sorting is difficult. The ore mined at the Superior in 1910 averaged, however, 22.64 pounds per ton. At the other mines the ore is more readily selected from waste.

The lode has not yet been explored to any great depth, and its possibilities have yet to be determined. Mr. Finlay estimated that the lode will produce about 15,000,000 tons of ore, containing about 311,000,000 pounds of copper. In this estimate he does not assume that the deposits will continue to very great depth, and if the values persist to depths found on the other great lodes, this estimate will, of course, be far exceeded.

The Pewabic Lodes are the productive amygdaloids of the Quincy mine, and are now being opened up at the Franklin Jr.

Instead of a single lode, there is, at the Quincy, a zone about 300 feet thick in which there are several lodes. These vary considerably in different parts of the mine. For the most part they run parallel to one another and are separated by trap. In places they come together. There is commonly one of the lodes that is better than the other and is known as the "main" lode. As the workings are continued this main lode becomes in places quite subordinate in importance to one of the "east" or "west" lodes. What is known as the main lode in one part of the mine is not called the main lode in another part. In places there are four parallel lodes being worked at once.

The beds, of which the lodes are the amygdaloid portions, are a series of dark grey feldspathic lavas, porphyrites, known locally as the "Ashbed" series. The amygdaloid shows chlorite, calcite, epidote, quartz, prehnite and native copper in a dark brown or grey groundmass. The trap is a fine, but distinctly grained, dark grey, porphyrite, spotted with small patches of green chlorite. The copper occurs to some extent as a filling in cavities, but most of it has evidently replaced the rock, and forms irregularly defined masses, large and small. The larger masses, giving so-called "mass copper," are more abundant than in most of the lodes. While [illegible] of the copper is found [illegible]

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with white calcite, which has been worked by the Osceola, Calumet & Hecla and Tamarack Mining Companies. On these properties

The lode is worked at the Isle Royale Mine south of Portage Lake. A similar, and probably the extension of this, lode was opened up north of Portage Lake at the Arcadian mine; but without success. At the northern end of the Isle Royale property, the beds strike S. 38° W., but further south bend westward until the strike is S. 58° W. The dip is to the N. W., at an angle of 56°.

From the workings on the Isle Royale lode another very similar bed, known as the Grand Portage and lying a short distance to the west, has been mined but its product not distinguished. The lode (or lodes) is comparatively low grade, and until recently has been mined at a loss. The production for 1910 averages 14.5 pounds per ton. Mr. Finlay estimates that it will produce 112,000,000 pounds copper above the 4,000 ft. level. Another recent estimate is that the Isle Royale contains 435,600,000 pounds of copper in ore averaging 14 pounds per ton.

The Atlantic Lode is a comparatively low grade bed, which was worked at the Atlantic Mine. It differs from most of the lodes in having the copper more finely disseminated through the rock. The upper part of the lode is fragmental, and contains sandy and epidotic portions, so that it has the appearance of a conglomerate, and has been called a melaphyre conglomerate. The lower part of the lode is an ordinary amygdaloid.

The Lake Lode is a wide amygdaloid the extent of which has not yet been determined. It is generally considered to be the best find in recent years in the district. In May, 1911, it had been opened up at the Lake Mine for a length of 2,100 feet, and a depth of nearly 1,300 feet on the dip. Where first found it strikes nearly north, but followed a few hundred feet to the north, it gradually turns to the westward, and at the end of some of the northern drifts, the strike is northwest. The dip is to the west and southwest. On the South Lake property, which adjoins to the westward, a similar lode strikes west and dips south. It is probable that this is a continuation of the Lake lode; but developement has not yet been carried on far enough to make this certain.

The lode at surface at the Lake Mine dips at an angle of about 36° A few hundred feet down it dips at about 34°. The South Lake drill holes give dips of beds to be to southward at angles of 55° to 58°. It is not unlikely that the discordance between the structure of the beds at the Lake Mine and the uniformly northwestward dipping beds of Evergreen Bluff has been partly brought about by faulting. No important fault has yet been definitely located however.

A. SHAFT HOUSES NOS. 1 AND 2 AT CENTENNIAL MINE.

B. ROCK HOUSES, OLD AND NEW TYPES, CENTENNIAL MINE.

A. SHAFT HOUSE AT BALTIC MINE.

B. ISLE ROYALE MINE.

A. ADVENTURE MINE, 1911. NEW VERTICAL SHAFT.

B. BALTIC MINE.

A. COPPER INGOTS ON DOCK AT HOUGHTON.

B. COPPER INGOTS ON DOCK AT HOUGHTON.

The amygdaloid is commonly of red-brown color, and spotted with amygdules of chlorite, calcite and other minerals. In places it shows much heavy copper, and resembles good parts of the Baltic lode. The value of the lower grade portions is not very definitely known, as comparatively little stoping has yet been done. The richer portions have proved to be wide and have been in places cut out for 40 to 60 feet. East of the main lode, the Lake Mine has opened up a second, but much narrower lode, sometimes rich in heavy copper.

At the South Lake property, rich drill cores were taken up, but the lodes have not yet been further examined. Shaft sinking was recently begun, but is temporarily suspended.

In smelting the small amount of copper produced in testing the Lake lode it was found that the copper is comparatively free of arsenic, although the lode is in a very low horizon in the Keweenaw series.

Mass Mine Lodes. At the Mass Mine there are four parallel lodes which have been opened up from one shaft. These are in ascending order, the Evergreen, Ogima, Butler and Knowlton. The Evergreen is a greenish amygdaloid, which contains copper in irregularly distributed masses, acccompanied by much finely crystalline or granular epidote and coarsely crystalline calcite. The Butler is an amygdaloid of unusual reddish color, having abundant reddish feldspar along with the more common minerals in the amygdules. It carries more regularly distributed small mass and stamp copper. The Ogima is a grey amygdaloid, spotted with epidote and chlorite. It rarely has any masses, but in places carries good values in fine or "shot" copper. The Knowlton is a reddish amygdaloid, resembling the Butler.

Forest Lode is amygdaloid, worked at the Victoria Mine. The bed dips N. W. at an angle varying from 61° at surface to 55° at the 15th level. The ore mined is comparatively low grade, yielding about 12 lbs. copper per ton.

Minesota Lode is a vein rather than a bed. It strikes with the formations in which it occurs, but dips somewhat steeper. The chief mineral constituents are epidote and quartz, and from the former it takes a yellowish green color. Scattered through this epidotic lode are masses of copper, and many have been taken out that weighed several tons. The largest mass mined from the lode is said to have weighed over 500 tons and was one of the largest produced in Michigan.

The Winona Lode is an amygdaloid worked on the properties of the Winona, King Philip and Wyandot Companies. It has yielded considerable copper at the Winona, and will in the near future be worked on a more extensive scale. The ore is comparatively low grade. That which was mined during the past year yielded about 13 lbs. per ton.

The Adventure lodes are three amygdaloids which have been worked by the Adventure Mine.

The Ashbed lode is an amygdaloidal porphyrite, which has been worked in the Eagle River section. It has copper finely disseminated through the rock, as in the Atlantic lode.

The Arnold lode is an ashbed worked at the Arnold mine.

Michigan Mine lodes. There are on the Michigan property a large number of lodes, including those worked at the Mass Mine and several others. The amygdaloids, in addition to the Evergreen series, are the Calico, North Amygdaloid and South Amygdaloid. The veins are known as the Minesota, Branch and Contact veins.

The Nonesuch lode is a cupriferous sandstone and conglomerate in the Upper Keweenawan. The bed carries copper in small particles, filling spaces between, and sometimes forming a coating on the sand grains. At the Nonesuch mine the bed is 4 feet to 8 feet thick. The coarser particles of copper are found in a friable sandstone. The more compact sandstone shows some very fine copper.

The Indiana lode. This deposit was located by drill holes, and little is yet known of its shape and size. The ore is native copper accompanied by calcite, quartz and epidote in a much fissured and altered mass of felsite. The available records are not sufficient to determine the shape of the felsite mass, and still less the extent of the deposit in the felsite. Exploratory work in now being carried on to determine the nature of the deposit.

The Algomah lode is the upper portion of a brown amygdaloid bed and differs markedly from all the lodes mentioned above in carrying black oxide, green silicate and green carbonate of copper instead of the native metal. It has been only slightly developed, and little is yet known of its character at depth. Along the strike it shows masses of green colored ore more or less separated by stretches of brown amygdaloid. The shaft sunk at an angle of 60°, follows the dip of the lode, and is 200 feet deep. At the shaft there is a stock pile of several tons of green ore. Sixty tons of selected ore showed 24% copper. Some similar deposits are reported to have been found in one of the upper levels at the Lake Mine, which adjoins this property on the north, and chyrsocolla has been found in drill cores from other neighboring properties.

The copper minerals in the Algomah lode are chiefly chyrsocolla, melaconite and malachite. The oxide is usually dull black massive melaconite; but Prof. A. E. Seamen has found specimens showing black tetragonal crystals of paramelaconite in green malachite. This is the only known occurrence of paramalaconite other than that at the Copper Queen Mine, Arizona, where it was first identified by Dr. Koenig. Prof. Seaman has also found in the Algomah ore some minute green crystals which are thought to be dioptase.

Hancock lodes. At the Hancock Mine there are three parallel lodes, known as veins No. 1, 2 and 3. One of these, No. 3, has been extensively opened up recently. It is a chocolate brown amygdaloid, spotted with very abundant amygdules of green chlorite. It has a thickness of eight to ten feet, and dips at an angle of about 45° in the present workings. The copper occurs in this lode, more largely than in many other lodes, in the amygdules. Many of the green spots of chlorite show copper when the rock is broken. The rock is soft. The bed where now being worked is remarkably regular, and has a very distinctly marked off hanging wall.

Hancock New No. 4 lode. A lode struck in November, 1911, at a depth of 3,105 ft. in the No. 2 vertical shaft is as yet not definitely correlated with other lodes, but is generally thought to be one of the so-called "west Pewabic" lodes.

The lode is a brownish gray amygdaloid, with very numerous amygdules. A rather unusually large number of the amygdules are quartz. Most of the others are calcite. The white calcite and quartz are often greenish in appearance, owing to the presence of chlorite scales and occasional epidote grains. Many of the joints in the rock are coated with quartz and calcite. On some of the joints there are fine scales of copper. Most of the copper is in the amygdules with the calcite and quartz; but some is in grains scattered through the matrix of the rock and some in seams of calcite and quartz.

The lode where cut is seven or eight feet thick of uniform ore, and there is also some ore further in the foot separated from the main ore body by a few feet of trap.

St. Louis Lode. This is a brown amygdaloid, from which several copper bearing cores have been taken, and which is now being opened up at the St. Louis mine. Where cut by 9 drill holes it showed widths varying from 8 to 39 ft.

CHAPTER IV.

CHARACTER AND VALUE OF THE ORE.

The ore is native copper with small amounts of native silver, in a gangue of either amygdaloid or conglomerate rock. Large masses of the metal, often weighing from a hundred pounds to several tons, are called *mass copper* or simply mass. Smaller masses are known as *barrel work*. Ore showing copper in comparatively small particles scattered through the rock, is known as *stamp rock*. Ore is commonly known as *copper rock*. The term *copper ore* is by Michigan miners often used only for copper minerals other than native copper; but the term is never used in this sense in this report. The native copper ore is by miners and unfortunately also by the mining companies commonly called rock. This unusual terminology is not here adopted.

Most of the mines produce some mass copper, and in a few it forms a considerable percentage of the output. In all the mines, however, ore which must be crushed and concentrated is the chief product, the individual particles of copper being commonly less than one-half inch in diameter, and usually less than one-quarter inch. The ore is very low grade, much lower than any other copper ore being mined, and carries on the average only about 1.3% copper. The average yield of all ore mined in 1910 was only 20.5 pounds per ton, and yet this was mined at considerable profit, with copper selling at 12.7 cents per pound.

The conglomerate lode being mined is richer than any of the amygdaloids. The former in 1910 yielded 28.3* pounds of copper per ton, while the amygdaloids yielded 18.2 pounds per ton. During the year there was milled 2,474,356 tons conglomerate ore, yielding 70,036,097 pounds copper, and 8,395,205 tons amygdaloid ore, yielding 152,647,364 pounds copper. Of the ore, therefore, 22.8 per cent was conglomerate, which yielded 31.4 per cent and 77.2 per cent amygdaloids, which yielded 68.6 per cent of the total copper. While the conglomerate is richer it is more difficult to drill and stamp.

The ore mined several years ago was much higher grade. The falling off in copper content is due partially to the fact that in

[1]These figures are from B. S. Butler's report in Mineral Resources of U. S., 1910.

some of the deep mines the ore at very low levels is not as rich as in the upper levels, and partially to the fact that improved methods make it now profitable to mine low grade ore that would not have been broken years ago.

Copper from the Michigan mines is unusually pure and commonly demands a somewhat higher price than copper from more complex ores. Some of the lodes give better metal than do others. Some are arsenical, due chiefly to presence of arsenides in viens cutting the lode. It has been noticed that the lodes in the lower part of the Keweenawan series are commonly higher in arsenic than those at higher horizons; but the newly found Lake lode which occurs low in the series is apparently an exception.

Native silver is commonly found in small amounts with the native copper, and in some few mines the silver is in commercial quantities. In 1910 the silver recovered from the ore mined in Michigan copper mines amounted to 330,500 ounces, valued at $178,-470.00. Only about one-seventh of the copper produced is electrolytically treated to save the silver. Some silver is picked out at the mills, but the amount obtained in this way is small.

The copper from concentrates carrying commercial quantities of silver is cast into anodes, and the silver is recovered electrolytically.

According to B. S. Butler the average ton of ore mined in 1910 produced copper valued at $2.54 and silver at 1.5 cents.

CHAPTER V.

METHODS OF PROSPECTING AND DEVELOPING DEPOSITS.

The method of prospecting in the Copper Country is now in almost all cases diamond drilling and trenching. The outcrops have long since been carefully looked over, but there still remains to be prospected a very extensive area, which is covered with glacial debris. The most notable new discoveries during the past few years have been made by drilling in such covered areas.

Exploration is also carried on underground at several mines. It is usual near an important lode to find parallel lodes which are not regular enough to be worked alone, but which carry at intervals copper in quantities sufficient to pay for extraction. In some mines prospecting for such deposits is carried on by systematic drilling into the foot or hanging from the workings on the main lode. In others, cross cuts are driven at less frequent intervals for the same purpose. In mines where a filling system is used, the rock cuts into hanging and foot are run far enough to explore other lodes.

In putting down the first drill hole in an exploratory campaign in drift covered areas it is the usual practice to set the drill at an angle normal to the dip as determined on neighboring properties. If the hole proves to be approximately normal to the bedding, other holes are bored at such distances that each will give a slight overlap over the section obtained in the next one. Many of the holes are drilled 1,000′ to 2,000.′ Where there is little known concerning the stratigraphy, the most satisfactory results are often obtained by vertical holes.

The cores drawn are closely examined for copper; and also for the purpose of correlating the various strata cut. Commonly all the core is kept regularly arranged in boxes. At intervals in the core-box a mark is made to indicate the depth from which the core was taken. After examination the cores are usually stored and kept for future reference.

Development. When a lode has been located, development is usually begun by sinking an inclined shaft in the lode or in the footwall. Exploration is carried on by drifts at levels about 100 feet apart. As a rule it has been found advisable in running these drifts, to follow the hanging or the footwall rather than to take straight courses. On the Calumet conglomerate the drifts are on the foot, but on most of the amygdaloid lodes the hanging wall is followed. This practice enables the miner to keep to a definite horizon, as the contact of the hanging wall trap with the lode is usually rather distinctly marked. Moreover, a bed that is cupriferous usually shows most regular ore shoots close to the hanging, so in *keeping to the hanging* the miner is, most of the time at least, *following the ore.* In a few mines the hanging is not very closely followed, but this is largely because in these mines the contact is not easily recognized. In another mine thousands of feet of drifts run in regular courses in the copper-bearing bed disclosed very little ore, while subsequent drifts following the hanging proved up very large deposits. The wisdom of keeping to the hanging was early recognized, and with a few exceptions the best results are still obtained in this way. There are some cases, however, in which it is perhaps just as well to follow the foot. In wide lodes there is usually much copper close to the foot, as well as close to the hanging. If then, the footwall is more easily identified than the hanging, as sometimes though rarely happens, it may be preferable to follow the foot. In the conglomerate mines the foot is followed because it presents a good fact to draw the cut to, rather than on account of the values there. As a rule drifts run without following closely the foot or hanging, soon get away from the ore, and are of comparatively little use in estimating the value of the deposit. There are, however, a few cases where the broken nature of the ground makes it practically impossible to follow foot or hanging closely, and then courses are run along the strike of the bed.

When it is desired to explore at depth the underlay of a lode productive on adjoining property, vertical shafts[1] are sunk and at various levels cross cuts run into the lode, which is then developed in the usual way. At some mines similar "deep" ore is reached by starting the shaft down at an angle of about 80° and curving at depth into the dip of the lode.

There are in Houghton county three vertical shafts that are very nearly one mile in depth, and several shafts on the slope of the lodes that are down over one mile on the incline. The deepest vertical shaft is 5,308.5 ft. and the longest inclined shaft is 7,995 ft. measured on the dip.

The ore cannot be satisfactorily sampled in the mine. After

[1]A description by W. E. Parnall, Jr., of the No. 5 Tamarack shaft was published in proceedings of the L. S. M. Inst., Vol. VII, 1901, pp. 50-61.

considerable ground is blocked out it is tested by a mill run extending over a few months. The usual practice is to rent a stamp at one of the mills and test the ore thoroughly before erecting a new stamp mill.

CHAPTER VI.

METHODS OF MINING.

As all the deposits being worked are in the form of inclined beds there is a marked uniformity in the way in which the lodes have been opened up. The method of mining the ore, however, is by no means the same for all the mines. The method adopted depends chiefly on the geological conditions, especially on the dip and thickness of the deposit and firmness of the lode and wall rocks. As a rule the copper deposits are in unusually uniform and firm rock that is easily supported. There are, however, some mines in which the lode or hanging wall is full of seams and joints, and the necessity of providing support has then made it advisable to use a different method of mining. The greatest similarity in methods is found in mines working the same lode.

There are also, however, notable differences in method which do not result from the geological conditions, and which may be seen on the same lode and often in the same mine. Very often stoping has been started near the shafts and advanced toward the boundary, while in other cases stoping has been begun at the boundary and advanced to the shaft pillar. The latter makes less support necessary, thus making it possible to allow the ground to cave soon after a stope is cleaned out, and at the same time renders protection for levels necessary only under the one stope being worked.

In some mines drifts are run of ordinary size 7′ x 7′ while in others the opening is carried forward as a drift stope, by cutting the full width of the lode and taking a few cuts off the back. The drift stope method gives a better opportunity to follow sinuosities of a lode closely, thus making possible a more definite estimate of its contents; but unless the lode is very uniform in grade there is likely to be broken rock that might be better left standing. In long drifts the better ventilation in the large opening is a decided advantage.

In wide lodes the ore is not as a rule evenly distributed, and a considerable percentage of the lode is worthless. There is then to be decided whether it is better to break the full width of the lode and sort out the waste, or to make the selection before breaking, and as far as possible leave the poor rock standing. The mines on one lode use the former method, while on another wide lode the latter system is utilized.

Methods of handling the ore differ largely according to the nature of the deposit and also for other reasons. In some mines mechanical scrapers are used in stopes, while hand shovels are used in others under similar conditions. In one mine chutes are used to load tramcars, while in another mine where the dip of the lode is practically the same, the ore is allowed to run down to the track level and then shoveled up into the cars. In most mines the men themselves push the tramcars, while in others rope haulage or electric locomotives are used. In most mines the ore is dumped directly from tramcar into skip, while in a few, ore pockets are used. In most of the mines ore is hoisted from every level; but in some the ore from four or five levels is run down in chutes and hoisted from one level.

The methods of mining in use will be best understood from brief descriptions of the practices in individual mines. The variations dependent on the nature of particular deposits will be brought out by taking as examples mines that are on different lodes. For the conglomerate lode we can take the workings tributary to one shaft at the Calumet and Hecla Mine; for an amygdaloid 14 ft. thick and with dip or 40°, the Wolverine; for a narrow amygdaloid at a steeper angle (45°), the Hancock; for deeper workings on a narrow amygdaloid dip 38° to 45°, the Quincy; and for a wide amygdaloid of steep dip (73°), the Baltic.

The Calumet and Hecla Mining Method. The Calumet and Hecla conglomerate is now being mined at great depth from several shafts, one of which is vertical and the others inclined. The lode averages 15′ in thickness, and dips usually at an angle of between 37° and 38°.

The incline shafts are sunk in the lode, and levels established at intervals of about 100 feet. Drifts 8′x8′ are run each way from the shaft to the boundary. A raise is put through for ventilating, and to provide a stoping face, and stoping is begun first at the boundary. A cutting out stope is run for 100′ by cutting a slice off the back for the full width of the lode. Then heavy timbers are put in to support the hanging and protect the level. No square sets are used. Heavy timber is placed as stulls, three large sticks being placed close together and forming a so called battery. Batteries of stulls are placed about eight feet apart, leaving a space of about five feet. In this space a chute is built at sufficient height to deliver the ore into tramcars. Above the chute the foot is covered with an iron plate 8′x4′ to enable the ore to run readily.

When stulls and chutes are in place heavy lagging is placed across the stulls, planks are placed over the timbers for the drillers, and regular stoping is commenced by breast cuts taking off 8′ to 12′ at a time. In each 100 ft. stope 2 or 3 drills work a short distance apart. As each cut is taken off the back, additional stulls are placed in line above the others. The broken ore falls down between the rows of stulls, and with some assistance from shovellers runs down to the chute and is loaded into tramcars. As the process goes on the ore is replaced by regularly spaced rows of stulls up to within a short distance of the next level. Stoping is carried on until all the ore is broken, no pillars being left anywhere in the stope. There are no arch pillars to support the levels above. The whole section of the lode is broken and swept down between the rows of stulls into the tramcars, mechanical scrapers being used to drag the ore down.

When the stope has been cleaned out, a solid row of heavy stulls is set across the foot of the stope, a considerable portion of the timber in the stope being robbed. The stope is then allowed to cave, the car tracks are taken up, and the thoroughly worked out part of the mine immediately abandoned. The 100′ block next towards the shaft is then attacked in the same way, and at the same time in the next lower level, stoping is begun at the boundary. Stoping is always done at several successive levels at the same time, and in any one level stoping is always being done in a block 100 feet nearer the shaft than the work in the next lower level. At the shaft a pillar 100 ft. wide is left on each side.

To work out a stope takes about eight months. Hence, stulls across the foot of the stope, while necessarily heavy, do not need to be of long lived wood. Consequently the heavy stulls are not of very valuable wood; but of timber common in the district—hemlock, birch and maple being generally used. The hardwood is used green and does not last long after it dries. Sometimes before a stope is worked out, caving starts in the level above, and small quantities of rock fall down onto the row of stulls. No damage is done, as the timber is still strong and the amount of caving slight. In a year or two the timbers have become weak, but by this time there are no miners in the stope below. At intervals there occur caves in the hanging and ultimately the stope is filled with the broken rock.

There is no sorting of the broken ore in the mine. Sometimes blocks of poor ground are left standing; but everything broken is hoisted. The tramcars are pulled to the shaft by air-engine rope haulage, and the ore emptied directly into skips. A seven ton skip makes seven or eight trips an hour to surface from a depth of 7,000 feet. At surface a little rock is picked out, as the ore is fed to the crushers.

The Wolverine[1] Mining Method. The Wolverine mine works a section of the Kearsarge lode, which here dips at an angle of 40.5° to 41.5° and averages 14′ in thickness. Shafts are sunk in the footwall and levels established at intervals of about 100 feet. Drifts are carried forward as drift stopes. The drift itself is about 6 by 7 ft. and the lode is cut out for its full thickness for a distance of 19′ from the foot rail. When the drift stope has been advanced a few hundred feet a block of ground 75′ long is marked off, and this is stoped out by four men on contract. The whole block is drilled by only one machine. A block is stoped out in about four months. The first block being raise and stope requires several weeks longer.

Owing to the dip there is no difficulty in rigging up drills on the foot, and at the same time the inclination is sufficient to allow all but the finest ore to run down to the level. No protection at the level is necessary, and no timber is used in the stopes. Rock pillars are left along the foot of the stope and a 8′ to 10′ floor pillar in the back. The ore runs onto a sollar beside the track, and is shovelled up into the cars. At the Mohawk mine where similar methods are used, the dip is in places not sufficient for the ore to run, and iron chutes are used in cleaning the stopes. A large number of cars are used at each level, and the trammers leave their loaded cars at the shaft. A special crew of workmen load all the ore into the skip, working their way down from level to level, and then riding up and going over the ground again.

Hancock Mining Method. At the Hancock Mine is illustrated an economical method of mining a narrow lode dipping at an angle of about 45°. In mining this lode use is made of a vertical shaft which is being sunk to open up the Pewabic lode at greater depth. In early workings an inclined shaft was sunk to the 13th level and three lodes opened up. The present method is in use below the 13th level on No. 3 lode.

A winze was sunk in the lode for about five hundred feet, and the lode worked from levels about 100′ feet apart. At the 18th level connection was made with the vertical shaft by a long cross

[1]A description of the Wolverine method will be found in Rickard's Copper Mines of Lake Superior and Crane's Ore Mining Methods.

cut. The winze was then no longer used for hoisting, but was converted into a chute, and all ore from upper levels brought down to this level.

Drifts are run 6'x7'. A cutting out stope follows enlarging the opening to 24'. A row of stulls 4' to 6' apart is set above the level and lagged over with cedar poles 4" to 6" diameter. At intervals of about 25 feet a hole 2'x4' is left in the lagging, and a high sollar built about 4' above the car rails. When the level is thus protected and provision made for handling the ore, stoping is commenced. In the first cut care is taken not to shoot the rock directly against the timbers. After a few feet of broken ore lies on the lagging, the remainder of the ore can be broken with wet holes. Enough ore is left in the stopes to support the miners and the rest drawn off. The ground is firm and no timber is used in the stopes. Rock pillars are left where poor rock is found, and an arch pillar, 6 to 10 feet thick, is left in the back of the stope to support the level above. The ore is drawn out of the stopes onto the sollars, and there sorted and loaded into tram cars. The cars are pushed by hand to the converted winze, which is now a chute having two compartments, one for ore and one for rock. At the bottom of the chute the ore is loaded into saddle-back tram-cars, each holding about three tons, and drawn by electric locomotive to the vertical shaft. Here the cars are run over bins into which their contents are emptied. From the bin the rock is let into the skip by raising a heavy gate, and dropping an iron lipped chute over the edge of the skip.

Quincy Mining Method.[2] At the Quincy Mine narrow amygdaloid lodes, dipping at an angle of from 54° to 38°, are being worked at great depth. The conditions are somewhat similar to those at the Calumet & Hecla conglomerate mine, but comparatively little timber is used. Support is chiefly by rock pillars, and by heavy stulls loaded with broken rock. Drifts, 7x6 feet are run in the lode. Commonly the drifts are partly in the footwall. The miners driving the drift are closely followed by others cutting out the lode for a width of 18 feet from the foot rail. Following the miners making the cutting out stope, come timbermen who protect the level and make provision for drawing off the ore into tramcars. When a cutting out stope has been timbered and the levels ready, drills are started in the stope. The several groups of men are all

[2]The Quincy method has been described by T. A. Rickard in Copper Mines of Lake Superior, and by G. R. McLaren, Journal of the Canadian Mining Institute, 1907, pp. 399-417. The methods have been somewhat changed since their descriptions were written.

gradually working their way from the shaft to the boundary.

The level timbering was formerly of stulls placed about 4 ft. apart and covered with cedar poles. The present method differs in the absence of lagging consequent on close spacing of the stull timbers. This gives better protection from falling rock and is said to be cheaper. The stull are logs of peeled hemlock, maple and birch, averaging 15″ to 24″ in diameter— some are 3 feet in diameter. These are set in a row at the foot of the stope, and are only four or five inches apart. At intervals of 15 ft. a 5 ft. space is left and a high sollar is built. A 2 ft. hole is left so that the ore can be run out on to the sollar. In some parts of the mine the ore is run out on timbers over the level and dropped into the car.

In stoping there are numerous pillars left scattered irregularly in the stope wherever the lode is poor or where support is especially required. Many are in places where the hanging bellies down. In places stulls are set in the stope for support, either as single sticks or in batteries of three. In some stopes the workmen stand on rock covered platforms supported by stulls and work down the stope from either side of a raise.

A common practice is to have three drills working on the face towards the boundary. Each takes off a slice by five or six breast cuts in descending order, and then goes up in the stope and works down again, taking off another similar slice.

When the stope is mined out, the row of heavy stulls at the foot is heavily loaded with rock. This "poor rock" is commonly obtained by breaking into the footwall, as it is desirable to disturb the hanging as little as possible. Rock is piled onto the stulls to a depth of 30 or 40 feet. Later, as the hanging settles down, the stulls are compressed—often splitting longitudinally, and shortening 6 or 8 inches—and then the rock filling, wedged tightly into place, takes up the pressure.

The ore is drawn off onto the high sollars and loaded into tramcars. For short distances, 500 to 600 ft., the cars are pushed by men. After the distance becomes greater, electric locomotives are used to haul trains of 4 or 5 cars loaded with about 3 tons each.

The ore is not loaded from tramcars into skips, but is emptied into ore pockets near the shaft. From these pockets, some of which hold 100 skiploads, the ore is drawn off* at a lower lever into the skip.

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*Diagrams illustrating arrangement for loading skip will be found in T. A. Rickard's "Copper Mines of Lake Superior," pp. 68 and 69.

The Baltic Mining Method. The Baltic is one of several mines on the Baltic lode, which is wide, 15′ to 60′ and has an unusually steep dip—73°.

Shafts are sunk in or near the footwall, and levels are about 100 feet apart. Drifts are either run 8′x8′ and then cut out the full width of the lode, or else run the full width at once. Then another cut is taken off the back, the drills being mounted on broken ore. There is then an opening 16′ high for the width of the lode. The ore is drawn off, and the broken waste rock left in piles in the drift. The levels are now enclosed by "dry" walls built of rock, and a cover of lagging laid on heavy timber caps. Openings are left at intervals in the wall for chutes to draw off ore through mill holes. The mills are built up with a circular wall of rock, leaving an opening about 4 feet in diameter. Iron lips are placed at the chute, so that the ore can be drawn off from the flat bottomed mill holes into tramcars.

When walls are built and mill holes started, the remaining space is filled with poor rock. Then stoping is started, the drills being rigged up on the waste. Where the amount of poor rock broken is too small for the filling required, additional rock is broken from the foot or hanging in "poor rock stopes." The ore broken is sorted where it falls. The waste is left to fill in the stope, and the ore is thrown into, or carried in small cars to the mill holes. Stoping proceeds in this way, the mill holes being built up and the stope filled with waste while the ore is being drawn off.

When the stope has been carried up to within about 30 feet of the next level, a so called caving method is used to remove the arch. A raise is carried up to the level, and numerous holes drilled in the ground on either side of the raise. When the level is no longer needed, a wide opening is made by firing all these holes, and the waste rock filling in the stope above follows the ore down into the stope below. The ore is sorted out and thrown into the millholes and then drills are rigged upon the waste filling in the stope, and slices are taken off the arch. When only a few feet remain a large number of holes are drilled nearly through to the level, the stope is well cleaned of ore, and then the holes fired. The broken ore falls down into the stope, and is followed by a pile of waste from the stope above. As much of the ore as possible is sorted out and thrown the mill holes. When all readily reached is sorted out, the drills are rigged up on the side of the pile of waste and another cut is made across the lode. Then again the stope is well cleaned of ore, and the last few feet of back is drilled with numerous holes. These are fired, and another cave of waste takes place. In this way all the lode is broken and most of the ore is saved.

A. OPENING UP AT ST. LOUIS MINE, 1911.

B. STARTING SHAFT SINKING AT ST. LOUIS MINE.

C. SINKING SHAFT IN OVERBURDEN, SOUTH LAKE MINE, 1911.

A. SOUTH LAKE MINE, 1911.

B. VERTICAL SHAFT (IN FELSITE) AT INDIANA MINE, 1911.

C. NEW BALTIC MINE, 1911

A. INSTALLING NEW HOIST AT LAKE MINE, 1911.

B. SKIPS AND MAN CAR AT RED JACKET VERTICAL SHAFT.

C. ONE OF THE CALUMET AND HECLA HOISTING ENGINES.

A. TAMARACK MINE.

B. RED JACKET ROCK HOUSE AND POWER HOUSE.

C. RED JACKET SHAFT.

CHAPTER VII.

CRUSHING AND CONCENTRATING THE ORES.

The ore in the mines when blasted commonly breaks for the most part into pieces that are readily handled by the trammers. Some large blocks are broken underground by hammer or powder. Some are broken by sledge or drop hammer at surface. The crushers[1] at surface are unusually large machines of the Blake type.

At surface the skips dump over grizzlies, small pieces of ore drop through and the larger slide down to the mouth of the crushers or into bins with chutes just in front of the crushers. There are numerous devices for handling the ore here. In some houses the ore is allowed to slide from the grizzly to a flat floor in front of the crusher. Workmen sort out the mass copper and waste rock, and feed the crushers entirely by hand. In several the ore is held back in bins, let into a chute by raising a gate, examined for waste rock or mass copper while in the chute, and then dropped into the crusher jaws by raising another gate. The gates are controlled by compressed air, and this power is also used in handling any large mass copper or waste rock which is not to go through the crusher. With the mechanical aids two men do easily as much work as six without, and as it is then only necessary to run the crusher one-half the time there is an important saving in steam. The method of handling boulders at the Calumet rock houses has been recently described in Engineering and Mining Journal, Jan. 20, 1912, pp. 159-160.

The rockhouses usually have large bins for storage purposes. Some of the newer ones, built of concrete and steel have a capacity of 700 to 1,000 tons. From these bins the rock is drawn off through chutes into railroad cars and taken to the mill. The masses which have been picked out are pounded by a drop or steam stamp until well cleaned of adhering rock and then shipped direct to the smelter. The mass as shipped averages 50% to 60% copper. The rock sorted out finds various uses. Much is crushed and used for railroad ballasting and for concrete. At some rockhouses the rock not crushed for other use is run down through chutes into the mine again and used to fill the stopes.

[1]For a description of the Calumet crusher by Claude T. Rice, see Eng. and Min. Jour., Nov. 25, 1911, p. 1026. An article on ore breaking methods written by W. R. Crane was published in Eng. and Min. Jour., Vol. 82, p. 768.

The mills of the copper country are remarkable for their enormous capacity. There are less than 100 stamps in the district, and yet the tonnage stamped daily is far greater than in any other copper district in America. In 1910 there was milled 10,869,561 tons, and a number of the stamps were idle. The recovery averages about 80%. The loss for most amygdaloids is 4 to 6 pounds copper per ton of ore. The loss in conglomerate ore is somewhat higher.

Steam stamps were early found to be well suited to crush the copper rock, and these have been improved until there are single heads which can crush 800 tons per day. Ordinarily the stamps average 320 to 700 tons per day, according to type of stamp, size of screen and kind of ore. The conglomerate is much more difficult to crush than is the amygdaloid, and considerable difference is found in the various amygdaloid lodes. Steeple compound heads have proven more efficient than simple heads, and most of the newer mills are thus equipped.

It has not been found advisable to crush the ore very fine with the stamps, as much of the copper is in coarse pieces and would be abraded by the stamps, and the fine crushing is done more effectively with other machines after the coarse copper has been saved. Conglomerate is stamped to pass 3/16" screen; but amygdaloid only to pass ⅝" screen. Chili mills are used for recrushing the coarser sands but these machines are being displaced by conical pebble mills. It is said that the latter not only do the work better, but are more cheaply and easily constructed, and will probably not spend such a large portion of their life in the repair shops.

From the stamps a product of heavy metallics is taken off by a hydraulic classifier or by a mortar jig. The pulp passes through a screen to jigs and tables. The jigs chiefly used are the Hodge and the Woodbury-Benedict. The tables concentrating sands are mostly Wilfleys and Deisters. For the slimes Evans round tables are commonly used.

The Calumet and Hecla stampmills,[2] the largest in the district, have 28 stamps, and in 1910 treated 2,795,514 tons of ore. The first product taken in the Calumet mill is heavy copper separated at the mortar. The conglomerate ore is crushed to pass a 3/16" screen, but a slot at the bottom allows large pieces of copper to drop into the sieve box of a mortar jig, while the lighter gangue and finer copper is kept back by a current of water rising through the slot. The

[2]A description of these mills by Robert H. Mauer was published in the Mining World, May 2, 1908, pp. 705-708.

coarser part is taken out by removing a plug above the screen, and the finer copper in the hutch is removed occasionally by opening a gate below. The pulp from the stamp passes through the 3/16″ screen and is carried to the first of a series of five Woodbury-Benedict jigs. From the first jig, called a classifier jig, slimes run off to a settling tank, and thence the overflow runs into waste launders, while the heavier slime goes to round tables and thence to Wilfley tables for the final concentration. Sands from the first jigs pass on to the other four jigs. Metallic copper is taken from the first two. The next three jigs give coarse copper-bearing sand, which is recrushed in a Chili mill and then concentrated on Wilfley tables. The hutch product from all five jigs is concentrated on other Wilfley tables. Copper is taken from each of the tables, and middlings are collected on another table for final concentration, and the middlings from this last Wilfley go to the Chili mill for recrushing.

In the Osceola mill,[3] using Norberg steeple compound stamps, with a capacity of 750 to 800 tons amygdaloid ore per day, the rock is crushed to pass 5/8″ screen. The stamp is fitted with a hydraulic discharge and lump copper is removed at the mortar. All but these large pieces of copper pass through the screen into launders. The launders are fitted with a hydraulic discharge, which takes off a product of coarse copper. The launders lead to trommels with 3/16″ punched holes. From the trommels, oversize goes to rolls for recrushing. Undersize goes to trough classifiers, which distribute sands to jigs and slimes to settling tanks and round tables. Products are taken from jigs, and by hydraulic discharges on way from rough to finishing jigs. Heads from the round tables, after settling, are treated on Wilfley tables.

During 1911 the Osceola mill has been greatly changed, and there are now only three heads working on the system just described. The others are being replaced by apparatus of the Calumet and Hecla type. Two of the new heads were quite recently completed. Two others are in process of construction. In the new units a coarse product is taken at the stamp by a Krause discharge and another product by bull jigs. At one stamp a hydraulic discharge is used to take off a product after the oversize from the trommels is reground by rolls. Undersize from the trommels passes on to Woodbury jigs and Wilfley tables as at the Calumet and Hecla mill. Sands are reground in Hardinge conical pebble mills.

[3]An article on practice at the Osceola mill, written by Mr. Lee Fraser was published in the Engineering and Mining Journal, June 22, 1907.

The concentrates produced at the mills contain varying percentages of copper. Concentrates from the conglomerate average about 50%, and concentrates from the amygdaloids average 65% to 78%. Each mill produces concentrates of several different grades, and these are in some cases numbered No. 1, No. 2, No. 3, and No. 4, the latter being the finest. The concentrates are commonly called "mineral," but there is no special advantage in this unusual practice. The No. 1, largely lump copper or metallic, is naturally the highest grade, and commonly runs over 90%, while No. 4 is of fine particles and comparatively low in copper content. Different systems of classifying the product are in use at various mills. At the Calumet & Hecla the mill products are now classed as No. 0 containing 90 to 92% copper; No. 1 containing 65 to 75% copper; No. 2 containing 20 to 30% copper; and No. 2 regrinder containing 30% copper.

The active mills are, with two exceptions, located on Lake Superior, Torch Lake or Portage Lake. One mill, the Victoria, is located at the mine on the Ontonagon River. The Winona mill is located at the mine near a small stream. Enormous quantities of water are used in the mills, and consequently as the streams near the mines are very small, lake shore sites are generally necessary.

CHAPTER VIII.

SMELTING AND REFINING ORE AND CONCENTRATE.[1]

Michigan copper ores are comparatively easy to smelt. The operations are chiefly, (1) melting the concentrates and mass in reverberatory furnaces, (2) refining the copper and (3) recovering what copper goes into the slag.

The chief product of pure copper comes from the first melting. The concentrates and mass are melted without, (or in some cases with) fluxes in reverberatory furnaces, the slag formed by adhering rock is skimmed off as it forms, and the copper refined in the same furnace, or at one plant in a second furnace. The whole process takes one day for a small furnace, (capacity 30,000 pounds copper) and longer for larger charges (80,000-150,000 pounds). When one small furnace is used for both melting and refining, it is charged in the afternoon, melting and skimming continued over night, and refining done in the morning. In refining, the melt is rabbled by compressed air several hours to oxidize impurities, principally iron and sulphur, which then come up to the surface and are skimmed off. In the process a little copper is oxidized. Some of the oxide is skimmed off with the impurities. The completion of the rabbling operation is determined by observation of the texture (granularity) of the copper in test buttons. When the original impurities have all been removed, the copper still contains some cuprous oxide—as much as 7%. This is reduced by submerging wooden poles in the melt. Poling is continued until the copper is in the best possible physical condition. This point is determined by observing test buttons until a stage is reached at which they set flat on cooling. There is then still some cuprous oxide, but the metal is in its best physical condition, and without further poling it is poured into moulds. This is the final product ready for market, and unusually pure. In one plant the copper is tested for conductivity before pouring, and if the test proves unsatisfactory the

[1]An account of copper smelting practice in Michigan written by H. D. Conant was published in the School of Mines quarterly, June, 1912. In the description here given I have made free use of his article which contains descriptions of the several plants. I have incorporated information obtained from several other smelter men. R. T. White described the Michigan smelter in Eng. and Min. Jour., Vol. 79, p. 842.

An historical account of the smelting practice was given by J. B. Cooper in proceedings of L. S. M. Inst., Vol. 7, pp. 44-49.

melt is rabbled and tested again before pouring. The completion of the poling operation is checked by a copper assay.

A smaller, but important, quantity of copper is obtained by treatment of the reverberatory slag. This is allowed to cool in deep pots and the copper settles to the bottom. The buttons are broken off and returned to the reverberatory furnace, while the slag, containing 15 to 30% copper, is melted in a cupola furnace with suitable fluxes. Limestone is added for all slags. For the ferruginous slag from conglomerate ore, a siliceous flux is necessary, and for the siliceous slags from amygdaloid ore, ferruginous fluxes must be added. Anthracite is added as a reducing agent. The fuel is coke and the anthracite.

The charge is treated slowly under a low pressure blast. As the melt is inclined to chill, deep crucibles are used to allow the copper to settle, and there is no forehearth. The slag is allowed to flow off continuously. The copper is run off at intervals and cast into blocks. These cupola blocks, containing small amounts of iron, sulphur and arsenic, are refined in the reverberatory furnaces in the same way as the copper formed on melting the original charge of ore and concentrates, but on account of greater impurity must be rabbled much longer.

To obviate dust loss in treating fine slimes, one smelter has a briquetting plant. The slimes are thoroughly mixed with lime and pressed into briquetts. These are sealed up in a steel cylinder and highly heated. They are then smelted with the reverberatory slag in a blast furnace.

At one plant the fines are melted in a reverberatory furnace and the product run off into pots. It is allowed to cool and then broken up for treatment in the blast furnace.

Casting methods differ at the different smelters. In some cases the ladle is brought over stationary moulds, while in others the moulds are moved up to the ladle. At the Quincy smelter the copper is dipped by hand ladles suspended from beams, so that they can be swung over the moulds. At the Lake Superior smelting works the moulds are brought up to the ladle on an endless chain. At the Michigan smelter, the moulds are brought up to the ladle by a Walker casting machine rotating in front of the furnace.

The copper is cast into several shapes, the most common of which are known as ingots, ingot bars, wire bars, cakes, slabs, billets and anodes. The ingots weigh about 20 pounds each, and are much used in manufacture of alloys. Ingot bars consist of two or three ingots joined together endways for convenience in shipping. For wire drawing, the copper is usually cast into rectangular bars, weighing about 225 pounds. Cakes, square or round, and weighing from 120 to 6,000 pounds are used for rolling into sheets. Slabs. are thin cakes. Billets are for manufacture into seamless drawn tubes. Copper containing appreciable amounts of silver is cast into anodes for electrolytic recovery of the white metal. Some cupola blocks, containing considerable impurities, are recast into anodes for electrolytic refining. No electrolytic copper is produced by the Michigan smelters. The anodes are shipped to a plant at Buffalo.

CHAPTER IX.

COSTS AND PROFITS.

The ore produced by Michigan copper mines is lower grade than that of any other district. Costs must therefore be very low in order that any profit can be made. The ore produced in 1910 yielded 20.5 pounds copper per ton. The conglomerate ore averaged 28.3 pounds and the amygdaloid 18.2 pounds. Figures showing the actual copper content of the ores treated are not available; but the recovery is thought to average about 80%. The conglómerate ore treated averaged about 35 pounds and the amygdaloid ore about 23 pounds copper per ton.

This ore is developed, mined, hoisted, crushed, transported several miles to mills, stamped and concentrated, and the concentrates transported to smelting plants, smelted and refined. The copper produced is transported to eastern markets and sold for about 14 cents per pound.

That the industry should be a profitable one is remarkable. Fortunately, the mode of occurence and the character of the ore are such that mining, milling and smelting operations can be carried on at unusually low cost. The unusually favorable location of the mines gives comparatively low transportation rates.

Eleven leading producers of amygdaloid ore report for 1910 costs for mining, transportation and milling to be between $1.28 and $2.00 per ton of ore. Seven of these companies report for 1910 cost of smelting and marketing to between 0.89 and 1.81 cents per pound of copper. The thirteen leading producers of amygdaloid ore report total costs for 1910 to be respectively, 11.05, 9.37, 11.57, 11.84, 14.48, 11.44, 8.32, 7.85, 12.17, 11.84, 10.53, 7.54 and 10.23 cents per pound of copper produced.

The conglomerate ore is much more difficult to mine and treat than the amygdaloid, and costs are consequently higher. For 1910 the Calumet and Hecla reports a cost of $2.11 per ton of rock mined, transported and stamped. The ore averaged 30.12 pounds copper per ton, and the total cost of production of refined copper was 8.55 cents per pound. The only other mine producing conglomerate ore was the Tamarack, and it made no profit in 1910 on ore averaging 21.1 pounds refined copper. The cost was 14.70 cents per pound produced.

Costs for each company for the years 1908, 1909, 1910 and 1911 will be found in the table in a later chapter of this report.

While the amygdaloid lodes and wall rocks are very firm and require little or no timbering, the conglomerate has a weak hanging wall which necessitates heavy timbering and increases greatly the cost of mining. The great depth to which the lode has been mined makes the cost of hoisting higher than in many of the amygdaloid mines. The conglomerate is much harder to drill and crush, and consequently the cost of mining and stamping must always be considerably greater than for amygdaloid ore. In spite of the greater costs per ton, the conglomerate is by far the most profitable lode, because of its higher values.

Many of the mines do not report costs of milling the ore. It probably averages in most cases over 20 cents per ton of rock stamped. The Osceola reported cost for 1907 to be 17.47 cents and for 1908 to be 15.78 cents. Transporation to the mills is an important item varying with length of haul. Smelting costs from one-quarter to one-half cent per pound of copper, and transportation and marketing takes another one-half cent per pound.

Owing to the low margin of profit, much attention is constantly given to devising cheaper methods. It is noteworthy that though the chief producers have to take their ore from ever increasing depth, and though the ore being mined is lower grade, yet during recent years a very steady improvement has been shown in the cost per pound of copper.

A very important feature of the past year has been the remarkably successful tryout of light weight one-man drills in competition with the heavy two-man piston drills of the ordinary type. Nearly all of the mines have been experimenting with the new drills, and in practically every case it has been found that they are preferable to the old type. In some cases one man with the light machine breaks fully as much ground as two with the old. There is good reason to believe that a considerable reduction in mining cost will result from the use of the light drills, and it will not be surprising if in a few years they displace the others altogether. In one mine using 40 drills the change has been made already. Two makes have proven especially successful. One of these is a piston drill and the other a hammer drill.

In the mills probably the most important saving in recent years has been made by the introduction of steeple compound heads. During the past few years much attention has been given to regrinding apparatus, and a considerable advantage is expected to follow the more general use of pebble mills. In addition to better recovery from new ore, large piles of tailings will probably be recrushed and concentrated at a profit.

Smelting methods do not change quickly. The chief changes introduced in new plants are the use of larger furnaces and more mechanical aids for the handling of charge and furnace products. By these means a considerable saving has been effected.

The copper mines have up to date produced about 5,345 million pounds of copper and paid dividends of $188,175,895 dollars.

Mr. Horace Stevens, who has made a special study of the situation states in his Copper Handbook:

"The average price received for all Lake Superior copper, from 1845 to 1910,, inclusive, was 14.19 cents per pound, with average dividends of 3.56 cents per pound, leaving an estimated cost of 10.63 cents for all years. While this may be accepted as an arbitrary figure, the cost might be figured much higher, or materially higher. By adding $60,000,000 to the cost of production, for money lost in unproductive ventures, the cost of copper produced would be made almost 11.5 cents per pound. By adding another $15,000,000 for assessments on mines that have since repaid in dividends the original assessments, the cost of copper would be increased to about 11.85 cents per pound, leaving a net margin of profit, for the entire production, of almost exactly two cents per pound, plus the present aggregate values of the mines, which would be about equal to total dividend disbursements to date, or about 3.5 cents per pound.

"Omitting the production of mines that have not proven profitable, the average cost of copper produced by dividend-paying Lake Superior mines probably has been about 9.5 cents per pound, for all years."

A discussion by J. R. Finlay of the costs at several mines is given in his book on "The Cost of Mining," pp. 127-164. Further notes on costs are included in his report to the State Tax Commissioners 1911.

CHAPTER X.

PRESENT CONDITION OF THE INDUSTRY.

During the past two years, and especially during 1911, the copper produced has been sold at unusually low figures. The domestic demand has been very unsatisfactory, and the price would have fallen still lower, but for a timely increase in demand by Europe. Foreign buyers took large quantities at around 12.5 cents per pound. Consumption during the year was greater than production, and in November the decrease in surplus stocks began to show marked influence on the price of the metal. Continued demand for large quantities soon forced the price up to over 14 cents, and the year closed with the market in very satisfactory condition. Good prices prevail and the surplus stock both in the United States and Europe has been considerably reduced. The improved price has prevailed too short a time to allow of very definite estimate of prices for the future; but it seems to have resulted directly from large consumption and low quantity of available stocks. If such is the case it seems likely that the price will be maintained, for the European consumption is expected to be very large, and the American consumers have comparatively small stocks on hand.

The following tables from statistics collected by the Engineering and Mining Journal shows the prices quoted for each month of the past five years, and the visible stocks in United States and Europe in each month of 1910 and 1911.

PRICE OF COPPER AT NEW YORK (in cents per pound).

	Electrolytic.					Lake.				
	1907	1908	1909	1910	1911	1907	1908	1909	1910	1911
January.........	24.404	13 726	13.893	13.620	12 295	24.825	13.901	14.280	13.870	12.680
February........	24.896	12 905	12.949	13 332	12.256	25.236	13.098	13.295	13.719	12.611
March..........	25.065	12.704	12.387	13 255	12.139	25.560	12.875	12.826	13.586	12.447
April...........	24.224	12.743	12.562	12.733	12.019	25.260	12.928	12.937	13.091	12.275
May............	24.048	12.598	12.893	12.550	11.939	25.072	12.788	13.238	12 885	12.214
June...........	22.665	12 675	13.214	12.404	12.385	24.140	12.877	13.548	12.798	12.611
July...........	21.130	12.702	12.880	12.215	12 463	21.923	12.933	13.363	12.570	12.720
August..........	18.356	13.462	13.007	12.490	12.405	19.255	13.639	13.296	12.715	12.634
September.......	15.565	13.388	12.870	12.379	12 201	16.047	13.600	13.210	12.668	12.508
October.........	13.169	13 354	12.700	12.553	12.189	13.551	13.646	13 030	12 788	12 370
November.......	13.391	14 130	13 125	12.742	12.616	13.870	14.386	13.354	12.914	12 769
December.......	13.163	14.111	13.298	12.581	13 552	13.393	14.411	13.647	12.863	13 768
Year...........	......	13.208	12.982	12.738	12.376	....	13.424	13.335	13.039	12.634

VISIBLE STOCKS OF COPPER

	United States.			Europe.		
	1909	1910	1911	1909	1910	1911
January........	122,357,266	141,766,111	122,030,195	124,716,480	244,204,800	236,629,120
February.......	144,130,045	98,463,339	142,439,490	118,574,400	248,236,800	236,992,000
March..........	173,284,248	107,187,992	156,637,770	117,140,800	254,150,400	233,385,600
April..........	182,279,902	123,824,874	162,007,934	115,024,000	249,625,600	223,014,400
May...........	183,198,073	141,984,159	165,555,908	114,050,320	246,870,400	212,284,800
June..........	169,848,141	160,425,973	165,995,932	127,352,960	239,142,400	202,540,800
July..........	154,858,061	168,386,017	157,434,164	150,928,960	232,892,800	195,932,800
August.......	122,596,607	170,640,678	137,738,858	171,492,160	222,320,000	191,891,840
September......	135,196,930	168,881,245	133,441,501	197,993,600	218,444,800	191,228,800
October........	151,472,772	148,793,714	140,894,856	210,224,000	211,276,800	191,945,600
November......	153,509,626	139,261,914	134,997,642	222,566,400	198,060,800	176,825,600
December.......	153,003,527	130,389,069	111,785,188	236,857,600	193,200,000	164,281,600
January......	. . .	. ....	94,784,178	... .	....	158,323,200

While the present price of copper is satisfactory and the immediate future is promising, it is the probably average price over a long period of years that most interests the mine owners. It is well known that there will soon be on the market a largely increased tonnage of copper produced by the comparatively new "porphyry" mines of the western states. If the "porphyry" copper is produced cheaper than that of Michigan, it is evidently of paramount importance to the stockholders of the older mines that this increase in output shall meet with a corresponding increase in consumption. If the increase in production is greater than the increase in consumption, then only those mines that can produce at low cost will be profitable and the others must close down. It has been claimed that the "porphyry" copper can be produced more cheaply than that of Michigan; but this remains to be proved. Mr. J. R. Finlay, a recognized authority on costs, has stated that it is highly doubtful if the average cost for the porphyry mines will be even as low as that in Michigan. In view of the fact that during the past there has been a fairly regular and large increase in the amount of copper consumed annually, it is reasonable to expect a large increase in the future. The larger market will probably readily absorb the copper from new sources, and the price will be quite as likely to rise as to fall. Mr. Finlay estimates 14 cents as a very conservative figure for the next ten years, and states that in his opinion the average price will be higher. It is interesting to note that Mr. Stevens' calculations show that the average price received for Michigan copper for all years 1845 to 1910 was 14.19 cents. Assuming a selling price of 14 cents, and consulting the production and cost sheet of this report it will be seen that large profits should be made in the future. It will be seen that in 1910 and 1911 over 99% of the total production is is made by 18 mines. It has been demonstrated that 13 of these the Ahmeek, Allouez, Baltic, Calumet & Hecla, Centennial, Champion, Isle Royale, Mohawk, Osceola, Quincy, Superior, Trimountain and Wolverine can make a profit with copper selling at under 14 cents. Four others Franklin, Mass, Victoria and Winona promise to show good results in 1912. The Tamarack has unusually high costs; but might show a profit on 14 cent copper.

Owing to the unfavorable market conditions, there has been during the past year no attempt to rush production. On the other hand there has been no great curtailment of output. The 1910 output was about 5% less than that of 1909, but the 1911 production is expected to be nearly the same as that of 1910, probably differing by less than one per cent.

One company, Ahmeek, paid an initial dividend in 1911. The eight dividend paying companies, Calumet and Hecla, Baltic, Champion, Osceola, Wolverine, Quincy, Mohawk and Ahmeek in 1911 distributed $5,376,125 to stockholders.

During 1911 the Franklin, Mass, Victoria, Winona, King Philip, Hancock and Ojibway called assessments for development work. The Adventure, Indiana, St. Louis, Old Colony and Mayflower called assessments for exploratory work, the first three for sinking shafts and drifting, the other two for diamond drilling. The Wyandot called an assessment to provide funds for the investigation of deposits found in a cross cut and for other exploratory work. The 1911 assessments totaled $2,086,299.

With copper selling at under 13 cents most of the dividend paying mines would probably produce in 1912 about the same amount as in 1911; but if a better price prevails an increase in output is to be expected.

The Ahmeek doubtless will show an important increase in any case, there being now a large tonnage of high grade ore available. The Mohawk has in the past few years developed at shafts No. 5 and No. 6 what is practically a new mine, and production can be much increased when desired. The Copper Range dividend producing mines, Champion and Baltic, are equipped to handle a large output, and if desired a considerable increase in production can be made. The Osceola output at present comes entirely from the Kearsarge lodes; but there is a large tonnage of ore on the Osceola lode that is developed, and which can be mined on short notice if the market warrants it. The 1912 production of Osceola, may therefore be about equal to that of 1911 or much greater, depending on operation on the Osceola lode. The Calumet and Hecla production from the conglomerate lode is not expected to fall off for several years, and when it does this can be partially offset by increasing production from the Osceola lode. The Wolverine mine has maintained a remarkably uniform production for several years, and the 1912 output will probably not differ much from other years. The Quincy, while maintaining a fairly uniform output in recent years, has made material additions to its reserves; and can greatly increase production when No. 9 shaft is sunk to the 22nd level and equipped for hoisting on a large scale.

Two mines not on the regular dividend list, Isle Royale and Trimountain, made profits during 1911, and are expected to make greater profits in 1912. The Isle Royale mine has shown considerable improvement in 1911, and is expected to show increased output in 1912. The Superior has one large body of high grade ore, but has not made a great production during the year, attention being chiefly devoted to developing the lode and improving methods of mining and handling the ore. The Centennial, which has been operated at a loss for several years, made a better showing in 1911, and is expected to about break even. An important additional source of copper for 1911 was the Winona, which produced no copper in 1908, 1909 or 1910; but came back on the list in 1911 with about 1,276,000 pounds. At the Hancock Mine in 1911, a mill test showed that the No. 3 lode can, by selection of the ore, be worked at a small profit, and the recent striking of a rich lode at the depth of 3,105 feet in the new vertical shaft, and the near approach of the shaft to the horizon of the Pewabic lode makes it probable that this mine will soon be an important producer. The Lake Mine, while not producing in 1911, is generally considered to be a very promising one. The ore body has been extensively developed during the year, and a hoist and rockhouse of large capacity are nearly ready for use. The Lake is expected to make a considerable output in the latter half of 1912. One large producer and former dividend payer, the Tamarack, has for some time been producing at a loss. During 1911 the working of the mine has been on a much smaller scale than formerly, and the year's production shows a falling off of about 3,500,000 pounds. The Michigan Mine, which was an important producer until two years ago, is closed down, but in 1911 was worked by tributors, and produced 327,773 pounds.

At the Mass and Franklin Mines, development work has during the past two years been far in excess of the production. These two mines have now large blocks of good ore developed and are installing hoists and rockhouses of increased capacity. They will in 1912 show a considerable increase in production.

More noticeable than at the mines is the cutting down of work on prospects. As elsewhere there is in this district always a desire to find copper in boom times; while comparatively little effort is made to find new deposits during a period of depression. During the past summer only very few diamond drills, in September seven, have been in operation exploring drift covered areas. Several of the properties on which copper beds were found by drills in 1909 and 1910 have been but little explored during 1911 because of the natural tendency of stockholders to hold back until brighter market conditions prevail. One property on which drilling showed exceptionally good cores is yet undeveloped, because the directors have not considered it advisable to do the necessary financing while there is so little enthusiasm. The drilling done in 1909 and 1910 showed conclusively how little is yet known of the possibilities of the Michigan copper district.

Of discoveries made in recent years, the most important are those in Ontonagon county at the Lake Mine and on neighboring properties. Exploration of the Lake lode was begun in 1906, and the work soon showed that an important new ore body had been found. Further development proved it to be rich, wide, and of considerable length and depth. The successful opening up of the new lode was naturally followed by exploration of the neighboring properties. There is a heavy overburden in the vicinity, and most of the prospecting was done by diamond drilling. It was found that the properties are well mineralized, and rich cores were taken from several holes, especially on the South Lake and Indiana properties. None of these deposits have yet been opened up.

In the northern part of Houghton county diamond drilling disclosed a promising lode on the St. Louis property, and a recent discovery in a drill hole on the Mayflower property will doubtless lead to more thorough prospecting of this section.

If, as seems likely, copper producers in 1912 receive a more reasonable price for their product, there will be much greater activity on the so called "drill hole" properties. There are very large areas of ground on the copper range that are yet untested.

From this account of the work done at the mines during the recent past, and the expectations for the immediate future, it will be evident that the period of depression in the copper market has acted as a check; but has not by any means demoralized the industry. It is unfortunate for the mine owners that they have had to dispose of so much copper at comparatively small profits; but they will reap some benefit in the future from the marked reductions in costs which have been brought about partly by the necessity of keeping the mines on a paying basis while the price was low. The mines producing over 90% of Michigan's copper in the past few years, did so at a profit. During this trying period many improvements have been made and new standards set. With normal prices again established, the mines are making better profits than would have been the case if necessity had not demanded the reforms sooner than they would have come in a period of brighter market conditions.

The industry is therefore in a very satisfactory state. The mines are in good condition to produce large quantities of ore at low cost, and a good price is being received for the product. During

A. TIMBER AT TAMARACK SHAFT.

B. ROCK HOUSE AND STORAGE BIN AT AHMEEK MINE.

C. SHAFT HOUSE AT NORTH KEARSARGE MINE.

A. MESNARD SHAFT, QUINCY MINE.

B. ROCK HOUSE AT SHAFT NO. 2, QUINCY MINE.

C. NEW ROCK HOUSE AT VERTICAL SHAFT, HANCOCK MINE.

A. DRILLING COMPETITION, HANCOCK, 1911.

B. DRILLING BY STEAM IN ST. LOUIS LODE, 1911.

C. SHAFT SINKING ON ST. LOUIS LODE.

A. AHMEEK STAMP MILL, TORCH LAKE.

B. TAILINGS CONVEYOR, WINONA STAMP MILL, 1911.

C. CALUMET AND HECLA STAMP MILLS, LAKE LINDEN.

the past two years there has been a notable decrease in the number of miners[1] employed; but if present conditions continue more men will be put at work. There were many idle miners in the district during 1911. A considerable number have left for other mining camps or for Europe, and the remainder have a very good chance of finding employment. To both mine owner and miner the immediate future looks bright. Even though 1912 should not prove to be the prosperous year that it gives promise of being, there is very good reason to believe that the Michigan copper mines have a long and profitable life ahead of them. There are known bodies of ore which will take many years to mine, and there is a large area of unexplored territory in which ore is very likely to be found. It is scarcely to be expected that another bonanza like the Calumet and Hecla conglomerate exists in the district; but that many millions of pounds of copper will be taken from deposits yet undiscovered is a prediction that can safely be made. It will take many years to thoroughly prospect the drift covered areas, and it would be very remarkable if they should be found to contain no profitable deposits. It is also likely that much copper will be found in old workings by more thorough investigation of the wall rocks.

[1] Very few of the miners are American born. W. J. Lauck in the Min. and Eng. World, Nov. 18, 1911, pp. 1013-14, discusses the Michigan copper miner of today. He states that 27% are Finns; 14% English; 10% Northern Italians; 10% Croatians and 5% French-Canadians. Others are Southern Italians, Slovenians, Poles, Swedes and Germans. Mr. Lauck estimated the average weekly wage earned to be $13.86. The highest wages are earned by Cornish and Finish miners. Of the immigrants from southern and eastern Europe only 5% have had experience in mining before coming to America. There are about 18,000 men employed at the mines at present.

CHAPTER XI.

MICHIGAN COPPER MINING COMPANIES.

ADVENTURE CONSOLIDATED COPPER CO., 32 Broadway, New York.

Capital Stock, $2,500,000 in 100,000 shares of $25 each. Balance of assets Jan. 1, 1912, $72,375.27.

James L. Bishop, President.

Chester L. Dane, Vice President.

These officers and Charles J. Devereaux, James S. Dunstan, William R. Todd, Stephen R. Dow, and Charles D. Hanchette, Directors.

William R. Todd, Secretary and Treasurer.

W. A. O. Paul, Assistant Secretary and Treasurer.

Charles L. Lawton, General Superintendent.

Mine at Greenland, Ontonagon County, Michigan.

This Company has worked several lodes in the Evergreen belt in Ontonagon County without any marked success. Up to Dec. 31, 1910, there had been produced 8,727,512 pounds of copper, which with a little silver, was sold for $1,351,181.35. The cost of mining and construction during the period was $3,120,176.04.

The work now being done is of an exploratory nature. By diamond drilling in 1908 and 1909 three copper bearing beds were located, and a vertical shaft has since been sunk to explore these at depth. The first lode was cut in the shaft at 894′ but has not been extensively explored. The shaft was continued down to a little over 1,500′ and a cross cut is now being driven at this level to investigate the other two lodes. The cross cut at the end of the year was in over 200 feet. It is expected to cut No. 2 lode at about 450 feet and No. 3 lode at 850 feet. Recently 6 feet of good ore was encountered in the cross cut; but its relation to the lodes cut by drill holes is yet rather uncertain.

AHMEEK MINING CO. 12 Ashburton Place, Boston.

Capital Stock $1,250,000 in 50,000 shares of $25 each. Balance of assets Dec. 31, 1911, $1,013,812.45.

Rodolphe L. Agassiz, President.

Quincy A. Shaw, Vice President.

George A. Flagg, Secretary and Treasurer.

These officers and Francis W. Hunnewell, Francis L. Higginson, Thomas N. Perkins and James MacNaughton, Directors.

Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mine at Ahmeek, Keweenaw County, Michigan.

This Company, controlled by the C. & H. Mining Company, is mining a rich section of the Kearsarge lode. It is practically a new mine and has a long life ahead. The lode is opened up by four shafts, two, No. 1 and

No. 2, following down on the dip from the surface, and two, No. 3 and No. 4, started in the hanging wall at an inclination of 80° and curving to the dip of the lode at depth. A large body of ore has been developed, and it is of unusually high grade, the 1910 yield averaging 22.3 pounds per ton, and that of 1911, 25.4 pounds. The production of earlier years was lower grade. During the past five years 1,722,281 tons of ore was stamped, yielding 35,911,797 pounds of copper, an average of 20.9 pounds per ton. This was produced at a cost of 13.3 cents and sold for 14.3 cents per pound. In 1910 there was stamped 530,365 tons of ore, yielding 11,844,954 pounds of copper. This copper cost 11.05 cents per pound. The 1911 production was 15,196,127 pounds copper from 548,549 tons ore. The cost per pound was 7.17 cents and the selling price was 12.78 cents. During 1911 the Company paid its first dividend, distributing $100,000 to stockholders. The net earnings for the year were $870,272.

The Ahmeek has been estimated to have a future production of 635,213,000 pounds copper to be produced from 80% of the lode averaging 18 pounds refined copper per ton. The probable cost for this production was estimated at 9 cents per pound.

Ahmeek has an enviable record, and has quickly taken an important place among the large producers. Ground was broken for the first shafts late in 1903. Since then two others have been sunk to reach the lode at depth, and a modern four stamp mill has been erected. In spite of the heavy items for construction, the company has accumulated a surplus and begun to pay dividends. With four shafts in operation, the mine is expected to make a much larger production in the near future.

The development at No. 3 and No. 4 shafts show a lower grade of ore than at No. 1 and No. 2 shafts and the copper is not so evenly distributed throughout the lode. During the year 38,450 tons of ore was produced from these workings.

At the stampmill Hardinge conical pebble mills were installed during the year to treat some coarse tailings from No. 1 and No. 2 heads.

ALGOMAH MINING CO. 60 Congress Street, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each, $10 per share paid in. 70,000 shares issued.

Balance of assets Dec. 31, 1910, $36,696.24.

Stephen R. Dow, President.

Albert L. Wyman, Secretary.

Alvin R. Bailey, Treasurer.

These officers and John C. Watson, John H. Rice, David E. Dow and R. M. Edwards, Directors.

R. M. Edwards, Superintendent.

Mine at Lake Mine, Ontonagon County, Michigan. Property 480 acres.

The Algomah Mine, which adjoins the Lake, is opening up a lode that is unique in the copper country. It is an amygdaloid with practically no native copper. The ore is black oxide and green chrysocolla occurring in rather irregularly shaped bodies in a brown amygdaloid. A shaft was sunk in the lode and at a depth of 104 feet drifts run along the strike 1,200 feet north and 850 feet south. Similar ore was found in varying amounts. At 1,000 feet north the drift reached the Eastern sandstone.

and for 200 feet the contact was followed. The shaft was also sunk to second level and has now reached a depth of 210 feet. From the shaft a cross cut is being driven west at the 210 ft. level to explore a lode which was cut by drill No. 2. The cross cut is in 350 feet.

At the 104 foot level a cross cut showed the amygdaloid to be about 40 feet thick and to lie about 60 feet above the contact of the Keweenaw series with the Eastern sandstone.

In addition to the work at the shaft, exploration has been carried on during 1911 on other parts of the property by diamond drilling. Two vertical holes were put down as far as possible, No. 5 to 2,241 feet and No. 6 to 2,538 feet. There are several lodes cut in No. 6 hole, one at 2,090 feet, 2,090 to 2,119 feet being particularly promising.

An assessment of $1 per share, payable Jan. 22, 1912, has been called to provide $70,000 for continuation of the development work.

ALLOUEZ MINING CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $22.25 per share paid in. Balance of liabilities Dec. 31, 1911, $77,700.04.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

G. A. Flagg, Secretary and Treasurer.

These officers and H. F. Fay, W. L. Frost, F. L. Higginson, F. W. Hunnewell, Thomas N. Perkins and James MacNaugton, Directors.

Geo. G. Endicott, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

This Company, controlled now by the Calumet and Hecla Mining Company, at first developed the Allouez conglomerate. The conglomerate workings were unsuccessful and finally abandoned. All work now is on the Kearsarge lode.

The Company does not own the outcrop of the Kearsarge amygdaloid, and the lode was reached, as at the Ahmeek, by steeply inclined shafts, which curve into the dip of the lode at depth. The ore is not nearly so rich as at the Ahmeek, but the Company is expected soon to become a dividend payer. During the past five years there was stamped 1,114,085 tons of ore, which yielded 17,355,301 pounds of copper, an average of 15.6 pounds per ton. It has been estimated that the mine will produce at a cost of 10.25 cents per pound, 282,317,000 pounds copper from ore yielding 16 pounds per ton. In 1910 there was stamped 247,119 tons ore, yielding 4,655,702 pounds copper, an average of 18.84 pounds per ton. This cost 11.57 cents per pound. In 1911 there was produced 288,160 tons of ore which yielded 4.780,494 pounds copper, an average of 16.56 pounds per ton. The cost was 13.30 cents per pound. The No. 2 shaft is now being equipped with a new hoist and rockhouse, so that the output can be greatly increased, and the latter half of 1912 should show a much larger production.

The drifting done during 1911 opened ground of average grade. The sinking at both No. 1 and No. 2 shafts showed only fair values. The No. 1 shaft is now 3,298 ft. and No. 2 is 3,228.5 feet deep.

ARCADIAN COPPER CO.

Succeeded by New Arcadian Copper Co.

ARNOLD MINING Co. 64-50 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

C. Howard Weston, President.

John Brooks, Secretary and Treasurer.

Capt. Wesley Clark, Superintendent.

Owns lands in Keweenaw County, including old Copper Falls mine and Arnold mine. The Copper Falls mine was an important producer years ago, but has long been idle.

ASHBED MINING Co. 64-50 State St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

John Brooks, Secretary and Treasurer.

Capt. Wesley Clark, Superintendent.

These officers and T. P. Farmer and W. C. Fiske, Directors.

Owns lands adjoining Arnold mine in Keweenaw County. Idle.

ATLANTIC MINING Co. 82 Devonshire Street, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets Dec. 31, 1910, $190,050.52.

Wm. A. Paine, President, Frederic Stanwood, Secretary-Treasurer. These officers and John R. Stanton, J. Wheeler Hardley, Frank P. Son, John H. Blodgett, and Samuel L. Smith, Directors.

F. W. Denton, General Manager.

Mine at Atlantic, Houghton County, Michigan.

The Atlantic Mine, now closed down, was until May 1906 a large producer. Settling of ground in old stopes, producing so called "air-blasts," put the mine out of commission at that date. The Company then directed attention entirely to exploration for the Baltic lode on section 16, a portion of the Atlantic property. A lot of work was done from the section 16 shaft, but all efforts to find the Baltic lode were unsatisfactory, and in June 1911, this exploratory work was stopped, and the shaft abandoned. The directors decided not to reopen the old mine on the Atlantic lode, because from the results obtained in the last five years that the mine was operated, they could see no profit in taking out the limited amount of ore that remains. An offer of the Copper Range Consolidated Co., to take over the Atlantic on the basis of one share in that company for ten shares of the Atlantic stock was accepted, and the bargain was closed July 1, 1911.

The Atlantic lode is comparatively low grade, averaging 14 pounds per ton, but the metal is rather evenly distributed, and the mine made a splendid record for low cost per ton of ore mined. Apparently in a period of good copper prices the ore could be taken out at a profit, and it is likely that at some future time the mine will again be opened up.

BALTIC MINING Co. 82 Devonshire Street, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets Dec. 31, 1911, $308,712.50.

Controlled by Copper Range Consolidated Company.

William A. Paine, President.

Frederic Stanwood, Secretary and Treasurer.

Wm. A. Paine, Samuel L. Smith, J. Henry Brooks, R. T. McKeever and Thomas S. Dee, Directors.

F. W. Denton, General Manager.

Mine at South Range, Houghton County, Michigan.

The Baltic, one of the best mines in the district, is mining a portion of the Baltic lode. The lode and method of mining have been described above. The mine first produced copper, 25,000 pounds, in 1898, and by Dec. 31, 1910, had produced 132,646,934 pounds and paid $6,550,000 in dividends. In 1910 there was stamped 781,419 tons of ore yielding 17,549,762 pounds of copper, an average of 22.46 pounds per ton. This copper cost 8.32 cents per pound, and was sold for 12.74 cents. The production for 1911 is expected to be considerably below that of 1910. This is due largely to preparations for working the lode from the boundaries towards the shaft.

The mine being a comparatively young one, little is yet known concerning the ore at very great depth. There is, however, no good reason to fear that values will not continue down to low levels.

The mine is now being worked from four shafts. It is planned to use one of these only to the limit of its present equipment and work the lower levels from three shafts only. To do the tramming in the long levels economically electric locomotives will be used. At the mill a number of changes have been made recently. Equipment for regrinding has been added, and a tailings conveyor plant was completed this fall.

Bohemia Mining Co. 85 Devonshire Street, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. 75,000 shares issued. $8 per share paid in.

Balance in bank April 17, 1911, $124,819.88.

William A. Paine, President.

Charles A. Snow, Vice President.

Robert H. Gross, Secretary and Treasurer.

These officers and Thomas S. Dee, Stephen R. Dow, John H. Rice and Richard M. Edwards, Directors.

R. M. Edwards, Superintendent.

Mine at Lake Mine, Ontonagon County, Michigan.

This company was organized to acquire and develop 960 acres of mineral land, lying about 1½ miles northeast of the Indiana property. During 1910 several holes were drilled in search of the Indiana lode. The work did not disclose any lodes rich enough to warrant further exploration under present conditions. The directors are awaiting developments on properties north and south, and during 1911 no work was done.

Of the six holes drilled, three showed some copper. From the cores considerable information concerning the geological structure was obtained, and this will be useful when further exploration is undertaken.

No. 6 conglomerate was cut by three holes and thus traced across the property. The contract of the Eastern Sandstone was found to be at about the middle of the south side of the property, thus showing probably 600 acres to be located on the Keweenaw series. The distance from the No. 6 conglomerate to the Eastern Sandstone was found to be 3,500 feet. This includes the horizon in which occur the new lodes on the Lake, Adventure and Indiana properties. Immediately below the No. 6 conglomerate several amygdaloids were cut, and some of these showed copper, and are possibly the beds being opened on the Adventure. The remaining two-thirds of the territory between No. 6 conglomerate and the Eastern Sandstone was cut by one line of holes near the south side of the property, and the ground there found to be much broken.

CALUMET AND HECLA MINING CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each, $12 per share paid in. Total dividends paid Dec. 31, 1911, $116,550,000.

On April 29, 1911, Cash and Quick Assets were $9,159,754.12. Liabilities, $582,897.84. Notes outstanding, $8,519,000.00.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

These officers and Francis L. Higginson, Francis W. Hunnewell and James MacNaughton, Directors.

George A. Flagg, Secretary and Treasurer.

Walter C. Smith, Assistant Treasurer.

James MacNaughton, General Manager.

John Knox, Jr., General Superintendent.

The Company owns the Calumet and Hecla properties and controls the following mining companies:

Ahmeek, Allouez, Centennial, Cliff, Dana, Frontenac, Gratiot, Isle Royale, LaSalle, Laurium, Manitou, Osceola Consolidated, St. Louis, Seneca, Superior, Tamarack and White Pine.

Calumet and Hecla Mine is at Calumet, Houghton County, Michigan.

The company has mines on three lodes—The Calumet conglomerate and Osceola and Kearsarge amygdaloids. About four-fifths of the production is from the conglomerate, and the balance from the Osceola lode. The Kearsarge is at present nonproductive on this property. The three lodes are described above.

The Calumet lode is mined from nine shafts, one vertical, seven following down on the dip of the lode from surface, and one slope shaft starting below the 57th level and running parallel to the lode, but at an inclination of only 22°.

The vertical, known as the Red Jacket, is a six compartment shaft 4,900 feet deep, equipped with a Whiting hoist. The inclined shafts are either two or three compartment. In the three compartment shafts the two hoisting compartments are given different numbers. Thus there are more numbers than shafts. South Hecla Nos. 9 and 10, for instance is one three compartment shaft with two skip roads. The 7 operating shafts on the lode from north to south have respectively the following depths:—6,155 ft.; 7,995 ft.; 6,186 ft.; 7,465 ft.; 7,570 ft.; 6,102 ft. and 7,529 ft. measured down on the incline. There are three additional shafts that are being gradually closed from the bottom by the removal of shaft and arch pillars, and four other shafts that have been for some time abandoned.

The mine workings are in four branches known as the Red Jacket, Calumet, Hecla and South Hecla. The Red Jacket and Calumet shafts are permanently bottomed, and the sinking in ground commanded by these shafts is by winzes and especially by the "slope" shaft from the 57th level. At the Hecla branch two shafts, No. 6 and No. 7, and at the South Hecla one shaft, No. 9 and 10, are still being deepened. The chief new ground found on the lode in recent years is south of this latter shaft at great depth.

During 1910 from the conglomerate mine there was hoisted and stamped 1,950,040 tons of ore, which yielded 58,739,509 pounds of copper, an average of 30.12 pounds per ton. This copper was produced at a cost of 8.55 cents per pound.

The C. & H. portion of the Osceola amygdaloid lode has been opened up by six three compartment shafts, all inclined with the lode. These in order from north to south had in April, 1911, reached depths of 1,234 ft.; 2,461 ft.; 2,787 ft.; 2,554 ft. and 3,232 ft. respectively. In 1910 there were hoisted and stamped 831,194 tons of amygdaloid ore, which yielded 13,150,427 pounds of copper, an average of 15.82 pounds per ton. The cost was 10.53 cents per pound. Most of the ore came from the hanging side of the lode, but much also from the foot. Considerable new ore has been found recently in the irregular foot portion.

The total ore, conglomerate and amygdaloid, stamped in 1910 was 2,795,514 tons yielding 72,059,545 pounds copper, an average of 25.77 pounds per ton. The copper cost 8.96 cents, and was sold for 13.20 cents per pound. In the last five years there was stamped 13,185,376 tons of ore which yielded 410,614,189 pounds of copper, an average of 31.2 pounds per ton. This copper cost 8.95 cents and was sold for 15.8 cents per pound. Production for 1911 is expected to be about 75,000,000 pounds. The selling price, however, is lower. It has recently been estimated that the conglomerate will yet yield 850,000,000 pounds of copper from ore averaging 30 pounds per ton, and the amygdaloid 630,000,000 pounds from ore averaging 14 pounds per ton.

Development work on the Kearsarge lode on the C. & H. property has been done from three shafts. Two of these were sunk each to 1,350′ and then closed down. The third was sunk to greater depth, and from it exploration is still being carried on. In 1910 there was stamped 14,280 tons of ore from the Kearsarge lode, which yielded 169,609 pounds of copper.

At the C. and H. mills the most noteworthy recent change is in the regrinding department. A regrinding plant built three years ago was equipped with 48 Chili mills. In competition with these two pebble mills have been running for some time. The management now considers a conical pebble mill to be the most efficient machine for the purpose. It has greater capacity than the Chili mill and on account of grinding finer permits of greater extraction. A new regrinding plant of 3,000 tons daily capacity, and in which pebble mills will be used is now being planned. The mills are now being built in the company's shops.

During 1910 the present recrushing plant treated coarse conglomerate tailings from the Calumet mill and produced 1,951,378 pounds of copper from sands containing 12.6 pounds of copper per ton, at a cost of 5.08 cents, exclusive of smelting and marketing costs. Experiments have shown that sands now lying in Torch Lake, and containing about 16 pounds copper per ton, can be treated at a substantial profit.

An event in 1911, which had an important bearing on the future of the Calumet and Hecla and subsidiary companies, was the proposal of a plan of consolidation of the Calumet and Hecla, Ahmeek, Allouez, Centennial, Seneca, Osceola Consolidated, Tamarack, Laurium, La Salle and Superior Companies. The several properties were appraised, and to each company it was proposed to allot stock in the new Company proportional to such valuation. March 15, 1911, was fixed as the date which the merger should take effect. The necessary majority vote was in favor of consolidation, but minority shareholders made vigorous opposition and took steps to prevent it. Suits were brought against it by G. M. Hyams as a shareholder in Osceola, by C. M. Turner and others also as shareholders in Osceola, and by F. W. Denton and W. A. Chadbourne as shareholders in Ahmeek. Hearings were had in each case and resulted in denial of application for temporary injunction by Judge Swan in the Hyams suit and by Judge Streeter in the Denton-Chadbourne suit. It was granted in Turner case by Judge Wiest, because of the excessive value of the properties which were to be capitalized at $10,000,000, the maximum allowed by Michigan law.

The Denton-Chadbourne case was later taken to the Supreme Court of Michigan, by a petition for a writ of mandamus, and a restraining order was issued pending the decision of the Court. A fourth suit was brought by J. F. Jackson, as a stockholder in Ahmeek, and a restraining order obtained, and an order to show cause why a temporary injunction should not issue was made.[1]

At this stage the Calumet and Hecla directors decided that the plan should be abandoned. They stated that the long delay and necessary attention from company officials was likely to render the scheme fruitless.

At present W. A. Chadbourne and others are seeking to obtain from the Courts a permanent injunction, which shall forever prevent a consolidation on anything like the terms proposed.

In Dec. 1911, counsel for the various interests agreed to drop the suits.

CARP LAKE MINING CO. Ontonagon, Mich.

Explored a copper bearing sandstone bed in the Porcupine Mountain district. Long idle.

CENTENNIAL COPPER CO. 12 Ashburton place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $19.50 per share paid in. 90,000 shares issued.

Balance of liabilities Dec. 31, 1911, $54,061.19.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

These officers and H. F. Fay, G. A. Flagg, F. L. Higginson, F. W. Hunnewell and James MacNaughton, Directors.

G. A. Flagg, Secretary and Treasurer.

Geo. C. Endicott, Assistant Secretary and Assistant Treasurer.

James MacNaughton, General Manager.

Mine at Calumet, Houghton County, Michigan.

Predecessors of this company explored without any satisfactory results the northern extension of the Calumet conglomerate. The present company explored the extension of the Osceola amygdaloid, with similar unprofitable results, and in recent years has confined attention to the Kearsarge lode. The lode is developed by two shafts of which No. 1 is 3,821 ft. and No. 2 is 3,955 ft. deep. The mine has made an important contribution to the copper output, but until 1911 has done so at a loss. During 1909 and 1910 costs were considerably reduced. Development work has been advanced, so that in a period of higher prices, a larger output may be made.

In 1910 there was stamped 102,133 tons of ore, yielding 1,572,566 pounds of copper at a cost of 14.48 cents per pound. The cost was reduced in 1911 to 12.69 cents on a production of 86,543 tons of ore yielding 1,493,834 lbs. copper an average of 17.26 lbs per ton. The chief development work during the year has been in the drifts north from No. 2 shaft at the lower levels where good ore has been blocked out. It is not unreasonable to expect better ore when these workings are continued to develop ground below the rich ore found in the South Kearsarge and Wolverine Mines. It is expected that there will be a considerable increase in production in 1912.

CENTRAL MINE, at Central Mine, Keweenaw County.

Formerly property of Central Mining Company, now owned by Frontenac Mining Company. Long idle.

CHALLENGE MINE, at Painesdale, Houghton County.

Owned by St. Mary's Canal Mineral Land Co. Idle.

CHAMPION COPPER CO. 82 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of assets Dec. 31, 1911, $792,256.14.

Controlled by Copper Range Consolidated Co., and St. Mary's Mineral Land Co. Mine operated by Copper Range Consolidated Company.

Wm. A. Paine, President.

Charles J. Paine, Jr., Vice President.

Frederic Stanwood, Secretary and Treasurer.

Wm. A. Paine, Charles J. Paine, Jr., Samuel L. Smith, George P. Gardner, Nathaniel H. Stone, F. W. Denton and Richard Olney, Directors.

F. W. Denton, General Manager.

Mine at Painesdale, Houghton County, Michigan.

This company is mining from four shafts a portion of the Baltic lode. The lode is described above. The method of mining is the same as that at the Baltic mine described above. The ore produced is comparatively high grade, and the mine is one of the most profitable in the district.

The mine first produced copper, 4,165,784 pounds, for the market in 1902. At the end of 1910 there had been produced 131,111,741 pounds, valued at $19,189,440.18 and paid in dividends $5,900,000.00. During 1910 there was hoisted and stamped 722,051 tons of ore, which yielded 19,224,174 pounds of copper, an average of 26.62 pounds per ton. This was produced at a cost of 7.85 cents, and sold for 12.74 cents. During the last five years there was stamped 3,651,132 tons of ore which yielded 88,460,380 pounds of copper, averaging 24.2 pounds per ton. This copper cost 9.25 cents and was sold for about 15 cents per pound. The mine is comparatively a young one, and is expected to be a large producer for many years. For 1911 the production will probably be considerably below that for 1910, and as the copper content and the selling price are lower, the profit has been much less.

At the stamp mill delays have been caused by trouble with the water intake, and a new intake is now being constructed.

Cherokee Copper Co. Houghton, Mich.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Jos. H. Hodgson, President.

Linus Stannard, 1st Vice President.

Deen L. Robinson, 2nd Vice President.

Wm. D. Calverly, Secretary and Treasurer.

These officers and J. H. Rice, B. M. Chynoweth and R. M. Edwards, Directors.

H. W. Fesing, Superintendent.

This company has been exploring, by diamond drilling, property lying between the Bohemia and King Philip properties.

Clark Mine.

Mine at Copper Falls, Keweenaw County, owned by Dr. Leon Estivant, 47 Ave. de l'Alma, Paris, France. F. W. Nichols, Agent.

Property was explored by diamond drilling in 1910. Now idle.

Cliff Mining Co. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. James MacNaughton, General Manager. Balance of assets Dec. 31, 1911, $75,756.59.

This Company, a subsidiary of the Calumet and Hecla Mining Company, owns a large acreage in Keweenaw County, including the old Cliff Mine. The Cliff Mine at one time was worked very profitably, and in 1849-1879 yielded dividends of $2,518,620. The copper was mined from fissure veins. Recently some work has been done in the horizon of the Kearsarge lode. The lode was approximately located by drilling, and an exploratory shaft started in August 1910. During 1911 a plant was installed, and the exploration continued. The shaft has been sunk to a depth of 217 ft. and at 205 ft. drifts were run north and south in the more easterly of two lodes found in the drill hole near the shaft. No copper was disclosed in either drift. A cross cut has been started from the north drift to reach the second lode. The horizontal distance between the lodes is 100 ft.

Contact Copper Co. 70 State St., Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each.

Harry F. Fay, President.

C. J. Morrisey, Vice President.

These officers and John C. Watson, Stephen R. Dow and John G. Stone, Directors.

This Company was formed in 1910, and took over the Elm River Copper Company.

The company in May, 1910, began diamond drilling in Section 13, T. 52, R. 36. Holes No. 1 and No. 2 penetrated the Eastern Sandstone. Holes No. 3 and No. 4 were abandoned in overburden after driving to depths of 502 feet and 322 feet respectively. Holes No. 5, No. 6 and No. 7 gave a continuous section southeasterly across the Keweenaw series. Hole No. 5 started near the west quarter post of section 12, was started in what is supposed to be conglomerate No. 7. The drilling shows the formations to strike N. 39° E. and dip about 64° N. W. and to be markedly free from evidence of disturbance.

COPPER CROWN MINING COMPANY. 1013 Eastern Ave., St. Louis, Mo.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Jacob Maurer, President.

Dr. M. J. Hopkins, Vice President.

N. J. Cashin, Treasurer.

These officers and B. L. Brown, Geo. Bridenbach, Fred Balke and J. W. Byers, Directors.

H. B. Kirkpatrick, Secretary.

The company owns a large acreage west of Victoria, Ontonagon County. The chief property is the Norwich mine, where some copper was produced. Now idle.

COPPER RANGE CO. 82 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Wm. A. Paine, President.

Chas. A. Snow, Vice President.

Frederic Stanwood, Secretary and Treasurer.

Frederick W. Denton, General Manager.

These officers and H. T. McKeever, Directors.

Controlled by Copper Range Consolidated Company. Owns one-half the stock of the Champion Copper Company and 9,360 acres on the mineral range.

The company did considerable exploratory work in 1909 and previously on lands under option from the St. Mary's Mineral Land Company. There was drilled 7,641 feet of holes, but nothing very promising was found and the option was dropped.

COPPER RANGE CONSOLIDATED COMPANY. 82 Devonshire St., Boston.

Capital Stock $38,433,500 in 384,335 shares of $100 each.

On Dec. 31, 1910, balance of assets was $641,726.22.

William A. Paine, President.

F. W. Denton and R. T. McKeever, Vice Presidents.

Frederic Stanwood, Secretary and Treasurer.

These officers and J. Henry Brooks, Kenneth K. McLaren, Charles J. Paine, Jr., F. McM. Stanton and Samuel L. Smith, Directors.

The company owns 99,659 shares of the Baltic Mining Co., 99,659 shares of the Copper Range Co., and 99,335 shares of the Trimountain Co. Through the Copper Range it owns the Copper Range Railroad, 9,360 acres of mineral land and one-half the stock of the Champion Mining Company. The Copper Range companies own 12,000 of the 20,000 shares of the Michigan Smelting Company.

The operating companies controlled by this company together in 1910 produced 42,468,754 pounds of copper, which was sold for $5,407,628.58. The net income for the year was $1,300,857.86. Dividends paid in 1910 amounted to $1,537,340.00, making a total of $10,756,716.00 paid in 6 years.

The production for 1911 was 37,130,292 pounds copper which was sold for $4,655,127.03. The net income for the year was $804,560.93 and $1,357,104 was paid out in dividends. The directors report an unsatisfactory year but a promising future.

DAKOTA HEIGHTS CO. Hancock, Mich.

Capital Stock $25,000 in 2,500 shares of $10 each.

Henry L. Baer, President.

Thos. Coughlin, Vice President.

Chas. D. Hanchette, Secretary and Treasurer.

Henry J. Brock, Superintendent.

These officers and Geo. H. Nichols, Jas. T. Healy, Frederick W. Nichols and Frank C. Mayworm, Directors.

Owns mineral lands in West Houghton adjoining the Isle Royale property. Idle.

DANA COPPER CO. 68 Devonshire St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

C. O. Burbank, Secretary and Treasurer; and John C. Watson and Joseph H. Chandler, Directors.

Is controlled by the Calumet and Hecla Mining Company. Owns lands in Keweenaw County, adjoining Central Mine. Idle.

DELAWARE MINE.

Is part of the property of the Manitou Copper Company in Keweenaw County. Former owners worked the Allouez conglomerate lode with very unsatisfactory results. The mine has been long closed down.

ELM RIVER COPPER CO. 70 State St., Boston.

Capital Stock $1,200,000 in 100,000 shares of $12 each.

H. F. Fay, President.

C. J. Morrissey, Secretary and Treasurer.

These officers and John C. Watson, Stephen R. Dow and Chas. N. King, Directors.

Geo. L. Goodale, Superintendent.

Owns property near Twin Lakes, Houghton County, and has done on it considerable exploratory work, chiefly by shafts and cross cutting. Was taken over last year by the Contact Copper Co. and the latter company has since been doing diamond drilling on the property adjoining.

EVERGREEN BLUFF MINING CO.

Owned property which adjoins the Mass Mine, and is now part of the holdings of the Mass Consolidated Company.

FRANKLIN MINING CO. 60 Congress St., Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each. $10.20 per share paid in. 166,326 shares issued.

Balance of liabilities Dec. 31, 1910, $46,687.44.

Stephen R. Dow, President.

Albert L. Wyman, Secretary.

These officers and John C. Watson, Harry M. Howard, Henry Tolman and R. M. Edwards, Directors.

Alvin R. Bailey, Treasurer.

R. M. Edwards, Superintendent.

Enoch Henderson, Asst. Superintendent.

Mine at Demmon, Houghton County, Michigan. Property 3,276 acres.

The old Franklin mine was nearly worked out, and sold in 1908 to the Quincy Mining Company. The Franklin Company is now operating the Franklin Junior mine, on property which adjoins the Quincy on the north. The company had on Dec. 31, 1910, stamped 6,311,176 tons of ore producing 160,595,837 pounds of copper. In 1911 there was produced 820,203 pounds.

Two lodes have been worked at the Franklin Jr.,—the Allouez, or Boston and Albany conglomerate, and the Pewabic amygdaloid. The conglomerate lode was abandoned in 1909, and the amygdaloid only is now being worked. Development work during the past two years has shown the lode to be richer at the deep levels than it was nearer the surface, and it is expected that the mine will become an important producer. A large tonnage of ore has been put in sight, there being in 1910 more than five times as much ground opened as stoped. During 1911 development work was put still further ahead, and the main shaft 3,320 feet deep, has been recently equipped to handle a much larger output. The other shafts are closed down. With the new hoist and a 10 ton skip, the shaft will have a capacity of 1,200 tons per day.

During 1911 the Franklin mill was thoroughly overhauled and is expected to make a better recovery of the values.

The new equipment at mine and mill was ready about Feb. 1, 1912 and regular mining operations were then resumed. During the month the output was increased from 250 to 650 tons daily and will be further increased as fast as miners can be secured.

FRONTENAC COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

James MacNaughton, General Manager.

These officers and F. W. Hunnewell, Directors.

Controlled by Calumet and Hecla Mining Company. Owns Central Mine and adjoining lands in Keweenaw County. Idle.

GLOBE MINE.

This mine, on property adjoining the Champion, was opened by the Copper Range Company to explore the Baltic lode. The results were unsatisfactory, and the property has been idle during the past two years.

GRATIOT MINING CO. 12 Ashburton Place, Boston.

Capital Stock $300,000 in 100,000 shares of $3 each, full paid and non-assessable.

Balance of Liabilities, Dec. 31, 1910, $266,133.07.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

These officers and F. L. Higginson, F. W. Hunnewell and James MacNaughton, Directors.

Geo. A. Flagg, Secretary and Treasurer.

W. H. Draper, Asst. Treasurer.

James MacNaughton, General Manager.

The company owns a portion of the Kearsarge lode north of the Mohawk mine, and has explored it with unsatisfactory results. The ore is low grade, and the company owns but a small area on the lode. In the eight months ending December 31, 1910, there was stamped 28,522 tons of ore, yielding 265,869 pounds of copper, of 9.32 pounds per ton. Development is by two shafts, one 1,901 feet deep, and the other 1,521 feet deep. The shafts would be useful in opening Seneca ground at somewhat greater depth.

HANCOCK CONSOLIDATED MINING CO. Hancock, Mich.

Capital Stock $5,000,000 in 100,000 shares of $25 each and 100,000 shares not issued.

Balance of assets Dec. 31, 1910, $48,599.99.

John D. Cuddihy, President.

Thomas Hoatson, Vice President.

These officers and Allen F. Rees, Samuel B. Harris, John H. Hicok, James Hoatson and Frederic W. Nichols, Directors.

John H. Hicok, Secretary and Treasurer.

John L. Harris, General Manager.

Mine at Hancock, Houghton County, Michigan.

The company is sinking a vertical shaft to work the Pewabic lode at depth, and incidentally has opened up some good ground on the Hancock lodes. The property adjoins the Quincy.

The vertical, which is a 9'x30' five compartment shaft, cut the No. 3 Hancock lode at a depth of 2,038 feet and was expected to cut the Pewabic lode at a depth of about 3,600 feet. On Nov. 29, 1911, the shaft at a depth of 3,105' cut into a rich amygdaloid lode, known now as No. 4 lode. This has not yet been definitely identified; but as there are known to be several lodes west of the Pewabic, it is thought that this is one of these. Where cut, the lode is rich for a thickness of about eight feet, and has considerable copper further in the footwall. As this ore has been found at a vertical depth of 3,105' it is evident that it may prove of great importance, even though it averages much lower grade than where now exposed. The shaft is close to the Quincy boundary, and the latter may also profit by the discovery. At a depth of 3,221 feet another bed showing some copper has been cut.

During 1911 the company mined enough ore on the Hancock lode to run a mill test. There was stamped 41,449 tons of ore, which yielded 754,749 pounds copper, an average of 18.21 pounds per ton. The ore was stamped at the Centennial mill, and the concentrates smelted at the Calumet and Hecla plant at Hubbell. The mill test was discontinued Nov. 1, 1911, and attention devoted to opening new ground by drifting and trial stoping. The vertical shaft is being deepened to cut the Pewabic lodes. During the last five months of 1911 the shaft was sunk and timbered for 405 ft., an average of 81 ft. per month, and on Dec. 31, 1911, was 3,197 ft. deep.

HOME COPPER MINING CO.

Owns land in Keweenaw County, adjoining the Humboldt Mine. Idle.

HOUGHTON COPPER CO. 713-199 Washington St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Chas. J. Paine, Jr., President.

Geo. P. Gardner, Vice President.

A. E. Coe, Secretary and Treasurer.

These officers and N. H. Stone, James P. Edwards and Frederick A. Nichols, Directors.

Dr. Lucius L. Hubbard, General Manager.

The company is exploring what is supposed to be the extension of the Baltic lode north of the Superior Mine. The lode was found by diamond drilling in 1910, and a shaft has since been sunk to a depth of 623 feet. The lode and wall rocks are much fractured. The shaft is in the footwall, and cross cuts are made to the lode. One was made at 460′ and in December, 1911, a cross cut was started at the 623′ level. Both these cross cuts opened up copper bearing lodes.

HULBERT MINING CO. 199 Washington St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

Albert S. Bigelow, President.

W. A. S. Crimes, Secretary and Treasurer.

Frederick W. Nichols, Agent.

Owns a large acreage of mineral lands in Houghton and Keweenaw County. Idle.

HUMBOLDT COPPER CO. 64-50 State St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

John C. Watson, President.

John Brooks, Secretary and Treasurer.

Capt. Wesley Clark, Superintendent.

These officers and M. A. O'Neil, Directors.

Explored long ago some lands in Keweenaw County. Idle.

INDIANA MINING CO. 60 Congress St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $8 per share paid in. 80,000 shares issued.

Balance of assets Dec. 31, 1910, $76,772.55.

Stephen R. Dow, President.

Albert L. Wyman, Secretary.

Alvin R. Bailey, Treasurer.

These officers and David E. Dow, Henry Tolman and R. M. Edwards, Directors.

R. M. Edwards, Superintendent.

Mine at Indiana, Ontonagon County, Michigan. 1,200 acres.

The company explored property in 1909, 1910 and 1911 by several diamond drill holes, and is now sinking a vertical shaft to examine copper bearing ground located by these holes. Rich cores were taken from a mass of much fractured and altered felsite, and in this rock the shaft is now being sunk. It is intended to sink the shaft deep enough to allow exploratory work to be done at the several depths from which copper bearing cores were taken. As little is yet known of the nature of the deposit, the plan of exploration seems a very wise one. The stratigraphy in the neighborhood of the shaft is apparently far from uniform, and deductions from the drill cores alone are unsafe.

Further to the northwest on the same property the beds appear little disturbed and with the usual regular strike and dip. Copper has been found in some of these beds also, and an exploratory shaft was recently started to test one of them. The shaft, known as "A" shaft, is 60 feet deep.

In the drilling campaign 14 holes were put down, making a total of 20,000′. In all but two holes copper was found. It is evident that the property, concerning which previously very little was known on account of lack of outcrops, is well mineralized.

The shaft started late in 1910 went through about 110 feet of overburden, most of which is a red colored lake clay. The ledge was reached April 4, 1911. Since then sinking has been continuously in felsite. The rock is hard, and has been found unusually difficult to drill. It is traversed by very numerous joints, and when blasted breaks into small fragments. The dump looks much like a pile of crushed rock, the pieces being nearly all less than 3″ in diameter. The shaft is on Jan. 1, 1912, 533 ft. deep and being sunk at the rate of 75 ft. per month. It is intended to cut a station at the 600′ level and run cross cuts to investigate the deposits found in No. 9 drill hole which is only 60′ from the shaft.

Previous to the discovery of the Indiana lode, the felsites were always thought to be barren of copper. From the drill cores obtained it seems that there is here perhaps a workable deposit, and the result of exploration is being awaited with unusual interest.

ISLAND COPPER CO. 1400 Alworth Bldg., Duluth, Minn.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

Thomas F. Cole, President.

Geo. G. Stone, Vice President.

Frederic W. Nichols, Secretary.

These officers and F. W. Heimick, Oscar J. Larson, Henry Nolte, Geo. G. Barnum, Geo. A. Tomlinson and Julius H. Barnes, Directors.

Edw. J. Maney, Treasurer.

The company owns the greater part of Isle Royale. Previous owners did a little exploratory work, but the present company has not yet done any. The island is largely composed of rocks of the Keweenaw series, and is known to contain copper bearing beds.

ISLE ROYALE COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $3,750,000 in 150,000 shares of $25 each.

Balance liabilities Dec. 31, 1911, $137,976.75.

Rodolphe L. Agassiz, President.

Quincy A. Shaw, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

These officers and Francis L. Higginson and Charles N. King, Directors.

Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mine at Houghton, Houghton County, Michigan.

The company is working the Isle Royale and Grand Portage lodes south of Portage Lake. The ore mined is comparatively low grade, and until recently much of the work has been done at a loss to the owners. A better showing has been made during the past two years. In 1910 there was produced 7,567,399 pounds of copper at a small profit. This copper was obtained from 520,860 tons of ore—an average of 14.5 pounds per ton. The copper cost 11.84 cents and most of it was sold for 12.68 cents per pound. During the last five years there was stamped 1,508,740 tons of ore, yielding 21,902,821 pounds of copper, an average of 14.6 pounds per ton. This copper cost 17.8 cents per pound and was sold for 14.2 cents. In 1911 production was 457,440 tons of ore which yielded 7,490,120 pounds copper, an average of 16.4 pounds per ton. This copper cost 10.85 cents per pound. The average price received for sales made during 1911 was 12.38 cents. There was received for silver in 1911 the sum of $20,336.55.

During 1911 extensive exploration work has been carried on at four shafts, No. 2, No. 4, No. 5 and No. 6 which have now reached depths of 3,162; 1,517.5; 1,006; and 1,234.5 ft respectively. The results are very satisfactory and the southern part of the lode, which has not yet been developed to any great depth, has been found rather above the average. The seventh level has been extended south to 1,932 ft. and has opened up good ground. In spite of the low price of copper and a slight decrease in output, the mine showed in 1911 a profit of $136,708.10. With better prices for the metal and a larger production, it is not unreasonable to suppose that the mine will soon become a very important profit maker. It has been found advisable to sort the ore carefully and the discard in 1911 amounted to 19.0% of the rock broken.

During the past few years the Isle Royale Company has done some exploratory work in the horizon of the Baltic lode. The ground has been found much broken up, and the results so far obtained are not very satisfactory. Some cross cutting and drifting was done during 1911 but no copper was found and the work at this point, "A" shaft, was discontinued in September. Further exploration at "A" shaft will depend upon results obtained by the Houghton Copper Co.

It is expected that the production of Isle Royale will be very considerably increased in the near future. At present the mill is being worked at its full capacity and increase in mine output will necessitate increase in milling facilities. The directors have recommended the purchase for the sum of $140,000 of a stock interest in the Lake Milling, Smelting and Refining Company, which will assure the use of two heads.

KEARSARGE MINE.

Is one of the producing mines owned by the Osceola Consolidated Company.

KEWEENAW ASSOCIATION. 33-87 Milk St., Boston, Mass.

F. M. Davis, Chairman.

Dudley S. Dean, Secretary and Treasurer.

John M. Longyear, General Agent.

Owns a large acreage of timber land and some mineral land on the range.

KEWEENAW COPPER COMPANY. Hancock, Mich.

Capital Stock $2,800,000. $14 per share paid in.

Thomas F. Cole, President.

Spencer R. Hill, Vice President.

Thomas Hoatson, 2nd Vice President and mining director.

C. A. Wright, Secretary and Treasurer.

These officers and James Hoatson, Directors.

The company owns a large acreage of mineral and timber lands in Keweenaw County. Some exploratory work has been carried on in the past few years chiefly by diamond drilling, and an exploratory shaft at Mandan. Copper was found in cores taken from the Kearsarge amygdaloid, and a shaft was sunk to a depth of 1,355′ to explore the lode. Comparatively little was found, and the work was recently discontinued.

KING PHILIP COPPER CO. 705 Sears Bldg., Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Charles J. Paine, Jr., President.

Geo. P. Gardner, Vice President.

These officers and Nathaniel Thayer, Charles J. Paine, Walter Hunnewell, Nathaniel H. Stone and Rufus R. Goodell, Directors.

Edward B. O'Conner, Secretary and Treasurer.

The company owns 960 acres in Houghton County, adjoining the Winona Mine, and works the same lode—the Winona amygdaloid. Recently the company has been merged with the Winona, and some reduction of operating costs should result. The two companies have recently erected a 2 stamp mill at the mine, and one head was put in operation in March, 1911.

The company has developed the Winona lode by two shafts, and put in sight a considerable tonnage of ore.

LAKE COPPER CO.

Capital Stock $2,500,000 in 100,000 shares of $25 each, all issued. $3 per share paid in. Balance of assets April 30, 1911, $357,988.79.

William A. Paine, President.

John H. Rice, Vice President.

Robert H. Gross, Secretary and Treasurer.

These officers and Galen L. Stone, William F. Fitzgerald, Robert T. McKeever and Reginald C. Pryor, Directors.

Charles K. Hitchcock, Jr., Mine Manager.

Mine at Lake Mine, Ontonagon County, Michigan. Property 1,150 acres.

This company is opening up a wide lode in the lower part of the copper bearing series. The lode has been described above. Development has until recently been entirely from one shaft. Drifts have been run at eight levels, and a raise put through for a new shaft on the lode. In May, 1911, the lode had been opened up for a length of 2,100 feet, and a depth of nearly 1,300 feet on the dip. Since that date the new shaft has been sunk to the ninth level, and drifts on several levels have been steadily extended. The old shaft is bottomed at a depth of 1,130′. The new shaft is 1,366′ and being deepened.

Under former management there was hoisted and stamped at the Franklin mill, 14,485 tons of ore, which yielded 318,050 pounds of copper, an average of 21.957 pounds per ton. During 1910 there was a change in management, and no ore has been stamped since. All efforts have been concentrated on development work, and the ore produced from these openings is piled at the surface.

In 1910 a new compressor plant was installed, and during 1911 a new hoist and rockhouse of large capacity have been erected. The development work is now well ahead, and with the new and well equipped shaft in operation, the mine can begin production very soon. Further extensive development work will probably be done however before mining on a large scale is begun. There are 8 levels developed and some dry walls similar to those at the Baltic Mine have been built preparatory to stoping.

Development has shown the lode to vary in strike from due north at the No. 1 shaft to due west at the end of the northern drifts. The structure is not yet well understood. The opening thus far made suggest that it may be a syncline pitching to the southwest.

LAKE MILLING SMELTING AND REFINING CO.
12 Ashburton Place, Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

This company controlled by Allouez and Centennial Mining Companies, owns the stamp mills at Point Mills, Portage Lake, and stamps the product of the Allouez and Centennial Mines. It is proposed to increase the capitalization to 250,000 shares and purchase the Tamarack two-stamp mill and 30% of the stock of the Mutual Light and Power Co. The Tamarack mill will then be enlarged and remodelled and used for stamping ore from Allouez and Centennial Mines, while the plant at Point Mills will be used for ore from Superior, Isle Royale and Hancock Mines.

LAKE SHORE MINING CO.
990 West Kensington Road, Los Angeles, California.

Capital Stock $500,000 in 20,000 shares of $25 each. Owns idle lands in Porcupine Mountain district, Ontonagon County.

LAKE SUPERIOR COPPER CO. Rockland, Mich.

Capital Stock $500,000 in 20,000 shares of $25 each. Owns idle property in Ontonagon County.

LAKE SUPERIOR SMELTING CO. 12 Ashburton Place, Boston.

Capital Stock $1,200,000 in 48,000 shares of $25 each.

Is controlled by Tamarack, Osceola and Isle Royale mining companies, and smelts ores from the mines owned by these companies, and from some other mines.

LA SALLE COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $10,000,000 in 400,000 shares of $25 each.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

James MacNaughton, General Manager.

These officers and F. L. Higginson, F. W. Hunnewell and C. C. Douglas, Directors.

W. C. Smith, Asst. Treasurer.

Controlled by Calumet and Hecla Mining Company.

This company has been exploring the Kearsarge lode, south of Osceola, Houghton County. The ore found so far is low grade, and the lode is in places very thin. During the last eight months of 1910 the company stamped 35,520 tons of ore, which yielded 472,100 pounds refined copper, an average of 13.20 pounds per ton. The 1911 output was much less than that of 1910. During 1911 exploration has been carried on from two shafts, and a large tonnage of ore developed; but it is too low grade to be produced profitably with the present equipment and prevailing low price of copper. Recently all work has been discontinued. It is proposed to do some exploring east of the Kearsarge lode.

The output for 1911 was 18,970 tons of ore yielding 280,598 pounds copper, an average of 14.77 pounds per ton. The development work was chiefly drifting at No. 1 shaft and drifting and sinking at No. 2 shaft. The No. 1 shaft is now 2,146 feet, No. 2 is 1,770 feet, No. 5 is 1,450 feet, and No. 6 is 882 feet deep.

LAURIUM MINING CO. 12 Ashburton Place, Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

James MacNaughton, General Manager.

These officers and Francis L. Higginson, Directors.

Geo. C. Endicott, Asst. Secretary and Treasurer.

This company, controlled by the Calumet and Hecla Mining Company, is exploring the Kearsarge lode at Laurium, Houghton County. The work being done is at one shaft 1,500 feet deep. Drifts have been run north and south at several levels, and some fair copper ground developed. The ore is too low in grade to be mined profitably at present.

MANITOU MINING CO. 12 Ashburton Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

James MacNaughton, General Manager.

These officers and Francis W. Hunnewell and Francis L. Higginson, Directors.

Geo. A. Flagg, Secretary and Treasurer.

Controlled by Calumet and Hecla Mining Co.

The Company owns a large acreage in Keweenaw County, including the old Delaware Mine. The Delaware worked extensively, but very unprofitable, a deposit in the Allouez conglomerate. The property has been for some time idle.

MASS CONSOLIDATED MINING CO. 79 Milk St., Boston, Mass.

Capital Stock $2,500,000. Capital paid in $2,300,000. Balance of assets Dec. 31, 1910, $130,069.73.

John W. Linnell, Jr., President.

Theo. O. Nicholson, Vice President.

Wilfred A. Bancroft, Secretary and Treasurer.

These officers and Wm. F. Fitzgerald, James B. Hill, D. A. Carrick and Fred J. Schultheis, Directors.

Elton W. Walker, Superintendent.

Mine at Mass, Ontonagon County, Michigan.

The company has for several years mined the Evergreen series of lodes in Ontonagon County. The operations, have, until recently, not resulted satisfactorily; but it appears now that the mine may yet prove a profitable one. A new system of mining and sorting the ore has proven more economical. More extensive development work has been carried on, and a large tonnage of ore put in sight. The company in 1911 purchased the Evergreen Bluff Mining Company's property adjoining the Mass Mine, and larger scale operations will now be possible.

In 1910 there was stamped 90,747 tons of ore, which yielded 1,321,885 pounds copper, an average of 14.59 pounds per ton. The average yield for 1911 has been higher than that of 1910, and it is expected that the average for the ore blocked out will be over 17 pounds per ton. During 1911 attention has been devoted to development work rather than to mining, and it has been found that the Butler lode carries ore more uniformly than was expected. The lode is on the whole not very high grade; but stretches of good ground have been blocked out, and will probably be mined at a profit.

At present one shaft, "C," is being equipped to handle a greater tonnage. Foundations for a new rockhouse have been laid, and a hoist of large capacity is to be installed. By the time the hoist is ready, there should be a large tonnage of ore developed, and the present output can be doubled. From the same shaft the Evergreen lode on property recently acquired can also be worked. At present the mine is producing about 300 tons per day and is expected to be producing 700 tons by July 1.

It has been found possible to sort the ore economically underground. One man sorts all the rock broken by one drill crew. As the ore runs down the stope, he sorts out trap and barren pieces of lode rock, and diverts them from the ore chute. Use is being made of the waste rock. The lode dips at an angle of about 45° and is about 9 feet thick. The levels are therefore protected by building one rock wall vertically from foot to hanging. Openings are left at intervals in the wall to draw off ore.

The mine had three shafts, known as A, B and C, in operation early in 1911; but the A shaft has been dismantled and its territory will be worked from B shaft. B shaft which is bottomed at the 18th level is in the Evergreen lode. It was until recently idle, and during 1911 much of the work here has been necessarily devoted to repairing the shaft itself, and unwatering the workings. Extensive development has been done, however, 2,503 ft. of drifting on the Butler and Evergreen lodes. C shaft which is 1,275 ft. deep is in the Butler lode, and it is on this lode that most of the development work has been done during 1911. There are, however, cross cuts to the other lodes at both B and C shafts, and from each of these it will be possible to work the Butler, Evergreen, Ogima and Knowlton amygdaloids. A small amount of work was done on the Knowlton lode in 1911 with fair results.

During 1911 the mine produced 73,475 tons of ore which yielded 1,326,898 pounds copper, an average of 17.58 pounds per ton.

MAYFLOWER MINING CO. 70 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Harry F. Fay, President.

C. J. Morrissey, Secretary and Treasurer.

These officers and John C. Watson, Stephen R. Dow, Manning Emery and John G. Stone, Directors.

Geo. S. Goodale, Superintendent.

The company holds property east of the Kearsarge and Wolverine mines in Houghton County. It has done considerable exploratory work east of the Kearsarge lodes, partly by shafts; but chiefly by diamond drilling. A campaign begun in August 1909 located the Eastern sandstone contact, at a point 330 feet south and 210 feet east of the S. E. corner of Section 8-56-32.

The work has been confined to the investigation of a zone 4,700 feet in horizontal width lying immediately west of this contact.

Recent drilling has disclosed a promising copper bearing bed at No. 16 hole at a depth between 1,328′ and 1,443′. According to Mr. Goodale's description the core from 1,328 feet to 1,349 feet and from 1,366 feet to 1,379 feet and from 1,386 feet to 1,405 feet shows a nearly continuous mineralization, with heavy small and fine copper.

No. 16 is a vertical hole located near the south quarter post of section 8, T. 56, R. 32. It is about 90 feet from the north boundary of Old Colony.

A vertical hole, No. 17, has since been sunk 200 ft. north of No. 16. As the beds dip to the west the new hole cut the lode at less depth. For 72 ft., from a depth of 1,016 to 1,088 ft. the drill was in a copper bearing bed. The sludge from this bed was kept in 15 parts according to depth, each part representing the fines made in 3 to 7 ft. of drilling. The assays given out show that the sludge averaged 26.25 lbs. copper per ton. Sludge from depth of 1,033 to 1,043 ft. averaged about 70 lbs. per ton. Copper was also found in many places from 1,094 to 1,159 ft. Another hole No. 18 has been started 250 ft. north of No. 16.

It appears that the Mayflower has an important ore body. The cores obtained indicate that the lode is thick and of good grade. It is reasonable to expect that development will show the deposit to be of sufficient size to be profitably worked.

MEADOW MINING CO. 50 State St., Boston.

Geo. Napier Towle, President.

John Brooks, Secretary and Treasurer.

Capt. Wesley Clark, Agent.

Owns lands in Keweenaw County adjoining the Phoenix Mine. Some mining was done on the Ashbed lode on the property years ago; but it has now long been idle.

MEDORA MINE.

At Mandan, Keweenaw County, is owned by the Keweenaw Copper Company. Idle.

MICHIGAN COPPER MINING CO. 15 William St., New York.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of liabilities, Dec. 31, 1910, $67,932.92.

Joseph E. Gay, President.

J. Wheeler Hardley, Secretary.

J. R. Stanton, Treasurer.

These officers and Geo. T. Roessler and Alfred M. Low, Directors.

Samuel Brady, Superintendent.

Mine at Rockland, Ontonagon County, Michigan.

On this property an unusually large number of deposits—amygdaloids and veins—have been worked. On Dec. 31, 1910, the mine had produced 16,670,438 pounds of copper valued at $2,515,934.19. One vein, the Minesota, was an important producer and returned profits in the early days. Most of the other lodes, while yielding considerable copper, have been worked at a loss and the mine was recently closed down. It is, however, being worked on tribute by 24 miners.

In 1909 there was stamped 148,172 tons of ore, which with 485,846 pounds of mass, yielded 1,979,305 pounds of copper. In 1908 there was stamped 190,331 tons of ore, which with 1,226,845 pounds of mass, yielded 3,000,206 pounds of copper. The percentage of mass was much higher than at other mines.

In 1910 attention was confined to exploratory work. Three holes were put down through the Ogima and Evergreen lodes, and copper found in encouraging quantities. Underground work was discontinued in January, 1911. Diamond drill work was continued until March 1st, and then all operations ceased.

During the year a number of miners have been "tributing" on what is known as the "Branch Vein," and it is expected that both men and company will make some profit from this work. The estimated output for 1911 is 327,773 pounds. While the company has done considerable exploratory work, it has still a large acreage that is untested.

MICHIGAN SMELTING CO. 82 Devonshire St., Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Wm. A. Paine, President.

John R. Stanton, Vice President.

Frederic Stanwood, Secretary and Treasurer.

Frederick I. Cairns, Superintendent.

These officers and Chas. A. Snow, Directors.

John Mugford, Assistant Superintendent.

The Company is controlled by the Copper Range and Mohawk-Wolverine Mining Companies, and smelts all the ore produced by them. The smelter is located west of Houghton on Portage Lake, and is the largest and most recently constructed one in the district.

MOHAWK MINING CO. 15 William St., New York.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets Dec. 31, 1910, $496,374.78.

Joseph E. Gay, President.

J. R. Stanton, Treasurer.

J. W. Hardley, Secretary.

These officers and Wm. A. Paine and Fred Smith, Directors.

Fred Smith, Agent.

Mine at Mohawk, Keweenaw County, Mich.

The company is mining a portion of the Kearsarge lode adjoining the Ahmeek property. The mine is one of the regular producers, and has returned large profits to the owners. The lode has been described above. The method of mining is very similar to that at the Wolverine, described above. The lode is opened up by six shafts. The chief production was for some time from the northern shafts; but the recent opening up of the southern part of the property has shown a large body of good ore there.

During the past five years there was stamped a total of 3,566,699 tons of ore yielding 52,415,939 pounds of copper, an average of 14.7 pounds per ton. In 1910 there was stamped 802,537 tons of ore, which yielded 11,412,066 pounds of copper, an average of 14.22 pounds per ton. The 1910 copper was produced at a cost of 11.44 cents and sold for 13.09 cents per pound. The ground opened in 1910 at the No. 4 and No. 5 shafts is reported to be higher grade than the average for the rest of the mine. The production in 1911 was 802,548 tons ore from which was recovered 12,091,056 pounds copper, an average of 15.07 pounds per ton. The recovery made was 76.71% of the copper content. The copper cost 10.399 cents and was sold for 12.63 cents per pound.

The Mohawk is one of the few Michigan mines that has mined copper arsenided from fissure veins in commercial quantities. Since the company has been conducting operations, it has sold mohawkite valued at $116,407.79. Little is now being produced however.

MULOCH MINE.

Is an idle property northwest of the Norwich mine, Ontonagon County.

NATICK COPPER CO. Houghton, Mich.

F. W. Nichols, Agent.

Owns idle lands adjoining property of the Frontenac Copper Co. in Keweenaw County.

NATIONAL MINING CO. 6 Beacon St., Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

B. T. Morrison, President.

Harry Highley, Secretary and Treasurer.

These officers and Chas. M. Baker, Harry M. Howard and W. S. Warn, Directors.

Owns the National Mine west of the Michigan at Rockland, Ontonagon County. Has long been idle, and no work whatever was done during the past year.

NATIVE COPPER CO. 68 Devonshire Place, Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

M. Augustus O'Neil, President.

John C. Watson, Secretary and Treasurer.

These officers and Ashley Watson, Arthur C. Paine, and Frank L. Van Orden, Directors.

Owns idle property in Keweenaw County.

New Arcadian Copper Co. Houghton, Mich.

Capital Stock $3,750,000 in 150,000 shares of $25 each.

Robert H. Shields, President and General Manager.

Col. Sylvester T. Everett, Vice President.

This Company succeeded, in 1909, the Arcadian Copper Company. It owns a large acreage east of the Quincy Mine in Houghton County. The old company opened up the northern extension of the Isle Royale by several shafts; but failed to get any satisfactory results. The new company has during 1910 and 1911 been doing considerable exploratory work, chiefly by diamond drilling but also by trenching and exploratory shafts. There are at present two drills at work, one in section 21 and one in section 31.

New Baltic Copper Co. 87 Milk St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Simon J. Beahan, President.

James P. Edwards, Vice President.

Robert H. Shields, General Manager.

F. H. Baird, Secretary and Treasurer.

These officers and J. B. Hardon, Directors.

The company owns Section 16, T. 55, R. 33, east of the Franklin Mine in Houghton County. Exploratory work was begun in 1909, and diamond drilling disclosed copper bearing beds in the lower part of the Keweenaw series. In 1910 an exploratory shaft was started to investigate the lodes located by the drills. At a depth of 360 feet cross cuts were run, and the lodes investigated. Recently the lodes have been opened up by a cross cut from the shaft at a depth of 500 feet.

New York Consolidated Mining Co. Houghton, Mich.

Frederic W. Nichols, Agent.

Owns idle property adjoining the Ojibway, Keweenaw County.

Nonesuch Mine. 78 Prospect Ave., Milwaukee, Wis.

Idle property in Porcupine Mt. district, Ontonagon County. The owners tested some time ago by diamond drilling and exploratory shafts, some cupriferous sandstone beds in the Nonesuch formation.

North Kearsarge Mine.

Is one of the chief producing mines of the Osceola Consolidated Mining Co. It is on the Kearsarge lode, north of the Wolverine and south of the Ahmeek.

North Lake Mining Co. 60 Congress St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $8.00 per share paid in. Balance of assets Dec. 31, 1910, $65,217.45.

Stephen R. Dow, President.

Albert L. Wyman, Secretary.

These officers and John C. Watson, Henry Tolman and R. M. Edwards, Directors.

Alvin R. Bailey, Treasurer.

R. M. Edwards, Superintendent.

Property at Lake Mine, Ontonagon Co., Mich. 1,120 acres.

The company has during the past three years been exploring its property by diamond drilling. Copper has been found in several of the fourteen holes, and it is expected that an exploratory shaft will soon be started to investigate some of the amygdaloid lodes located by the drills. In Dec., 1911 the 14th and last drill hole is being sunk, and is now down 450′. The total exploratory work in 1911 was 3,211′.

Drilling showed much of the ground to be underlain by the regularly bedded northwesterly dipping formation; but some of the holes near the eastern part of the property revealed the presence of a mass of felsite similar to that on the Indiana property adjoining. Considerable chrysocolla and native copper was found in the felsite, but additional holes did not show any regularity in the shape of the rock mass, and further work on this deposit will not likely be done until the deposit in felsite on the Indiana property has been opened up and its nature better known.

To explore the several amygdaloid beds a vertical shaft is to be sunk and all the beds showing copper will be tested by drifts and cross-cuts at a depth of about 1,000 ft. The shaft will be started close to No. 3 drill hole where there is very little overburden.

Ojibway Mining Co. 1400 Alworth Bldg., Duluth, Minn.

Capital Stock $2,500,000 in 100,000 shares of $25 each. 84,000 shares issued. $12 per share paid in.

Balance of assets Dec. 31, 1910, $34,391.48.

Lucius L. Hubbard, President.

Charles A. Duncan, Vice President and Treasurer.

Oscar J. Larson, General Solicitor.

These officers and Thomas F. Cole, Chester A Congdon, Charles D'Autremont, Jr., James Hoatson, Thomas Hoatson and John D. Ryan, Directors.

William G. Hegardt, Assistant Treasurer.

Frederic R. Kennedy, Secretary.

Daniel R. Smith, Asst. Secretary.

Henry B. Paull, Auditor.

Andre Formis, Superintendent.

Mine at Ojibway, Keweenaw County, Mich.

The Ojibway has opened up the Kearsarge group of amygdaloid beds, and during the last two months of 1911 produced 5,203 tons of ore. The lode being mined is developed by two shafts, which had on Dec. 13, 1911, reached depths of 1,954 and 1,617 feet. The work done so far has shown good copper ground in several openings, and a zone of barren or faulted ground, 250 feet in width, that runs diagonally from south to north across No. 1 shaft. From the bottom of No. 2 shaft some exploratory work has been done by diamond drilling.

It was stated by the president of the company during the year, that not enough ground has yet been opened up to permit of production on a profitable scale; but with an adequate tonnage of equal value with that now available, there is no doubt that ore can be produced at a profit.

To determine definitely the average values in the ore, preparations were made for a mill run to extend over several months, and on Nov. 1, 1911, shipments to the Tamarack mill were begun.

All the ore is being hoisted from No. 1 shaft, and No. 2 shaft is at present closed down.

OLD COLONY COPPER CO. 70 State St., Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Harry F. Fay, President.

C. J. Morrissey, Secretary and Treasurer.

These officers and John C. Watson, Stephen R. Dow, F. L. MacQuire and John G. Stone, Directors.

Geo. C. Goodale, Superintendent.

Property at Calumet, Houghton County.

The company has done considerable exploratory work on its lands by shafts, a long cross cut and diamond drill holes. The property lies east of the Calumet mine, and is underlain by the lower portion of the Keweenaw series. In July, 1911, the company began the exploration by diamond drill of a zone, approximately 2,100 feet in width, which at the southern boundary of the property lies next to the Eastern sandstone. The contact between the latter and the trap series was found at a point 440 feet west and 70 feet north of the south quarter post of Section 17, T. 56, R. 32. The dip of the contact to a point 800 feet from surface (inclined measurement) is to the west at an angle of 24 degrees, and three holes in nearly one vertical plane show the line of dip to be practically straight for a distance of at least 500 feet. The dip of the formation 300 feet above the contact is 43 degrees. The Mayflower, drilling, where it was possible to arrive at a definite conclusion, showed the dip of the formation to be 50 degrees.

Some copper bearing beds were located by the holes, and the company hopes to find a continuation of the ore body found by diamond drilling on the St. Louis property to the south.

One complete section across the zone being investigated, was made by holes No. 7, 8, 9, 10 and 11. These holes have a total length of 3,042 feet. A second section is now being made, and the first hole, No. 12, has been started at a point about 500 feet north of No. 11.

The recently located copper-bearing bed on the Mayflower property was found by drill holes put down vertically about 90 feet north of the Old Colony boundary. It is therefore likely to be found on the latter property also.

ONECO COPPER CO. 64-50 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets March 1, 1912, $11,699.

John D. Cuddihy, President.

John Brooks, Secretary and Treasurer.

John L. Harris, General Manager.

These officers and Wm. F. Fitzgerald, Geo. Napier Towle and John C. Watson, Directors.

The company owns 800 acres southeast of the La Salle, Houghton County.

During the past few years several holes have been drilled and copper bearing veins been obtained from two amygdaloid beds. In 1910 an old shaft was reopened, and during 1911 this has been deepened. Cross cuts have been run at intervals to intersect the lode. The shaft is on March 1, 1912, 1,110 feet deep.

OSCEOLA CONSOLIDATED MINING CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets Dec. 31, 1911, $1,832,183.52.

Rodolphe L. Agassiz, President.

Quincy A. Shaw, Vice President.

George A. Flagg, Secretary and Treasurer.

These officers and Francis W. Hunnewell, Francis L. Higginson, T. Nelson Perkins and James MacNaughton, Directors.

Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mines at Osceola, Kearsarge and Tamarack, Houghton County, Mich.

The company owns four mines—Osceola, Kearsarge, North Kearsarge and Tamarack Junior. The Osceola mine is on the Osceola lode, south of the Calumet and Hecla mine. The Kearsarge and North Kearsarge are on either side of the Wolverine mine on the Kearsarge lode. The Tamarack Junior mine is on the Calumet conglomerate, north of the Red Jacket shaft of the Calumet and Hecla.

The Tamarack Junior was unprofitable, and was closed down in 1903.

The Osceola mine was for some time an important producer and profit maker. The north end of the property yielded ore of good grade; but as work advanced southward from the early openings, poorer ore was encountered, and as operation was then at a loss, the mine was on March 1, 1910, temporarily closed down. The No. 5 shaft is 4,623 ft. and No. 6 is 4,592 ft. deep. Alterations and repairs have been made, and it is expected that more economical operation will be possible when the mine is again opened up. The southernmost shafts have been overhauled, and the rock-houses improved. The reopening of the mine will depend partially on the market conditions, as it is not thought advisable to resume operations while the price of copper is low, and partially on the progress made in remodelling the stamp mill, as two heads are at present out of commission.

The falling off in production consequent on the closing down of the Osceola branch, has been partially offset by increased output from the two mines on the Kearsarge lode. At the South Kearsarge No. 1 shaft is bottomed at 2,805 ft. and No. 2 shaft at 1,992.5 ft. At the North Kearsarge No. 1 shaft is down 3,873.5 ft.; No. 3 shaft 3,192 ft.; and No. 4 shaft 1,449 ft. The only sinking done during 1911 was 306 ft. at No. 4 North Kearsarge. Sinking at No. 3 has been started.

In the period of five years 1906-1910 the Osceola Consolidated stamped 5,781,808 tons of ore, yielding 98,617,221 pounds of copper, an average of 17.2 pounds per ton. This cost 10.53 cents, and was sold for 15.2 cents per pound.

During 1910 there was stamped 1,217,720 tons of ore, yielding 19,346,566 pounds of copper, an average of 15.9 pounds per ton. This copper cost 9.37 cents per pound. The lower content per ton for the year's output is reported to be due to the workings during this period in the North Kearsarge mine being below average grade. In 1910 South Kearsarge ore averaged 18 pounds and North Kearsarge 14.7 pounds copper per ton. It has been found advisable to modify the washing apparatus at the stamp mill. Woodbury-Benedict jigs and Wilfley tables have been installed in place of other jigs, and Hardinge conical pebble mills are now used to regrind the sands. Two sections have been recently completed and two others are in process of construction. It is stated that the remodeled milling system extracts 79% of the copper compared with 73% under the old system. About $70,000 was spent in changing the two sections and it is estimated that the cost to complete the remodeling will be $175,000. The capacity of the new head is the same. The cost for treatment is increased about one cent per ton of ore. The production for 1911 was 1,246,596 tons ore yielding 18,388,193 pounds copper at a cost of 9.28 cents per pound. The average yield was 14.8 pounds per ton. South Kearsarge ore averaged 18.2 pounds per ton. The development work at South Kearsarge is practically completed and mining costs will be low. At North Kearsarge the ore opened up is below average grade.

PACIFIC COPPER CO. 705-199 Washington St., Boston.

Capital Stock $1,250,000 in 50,000 shares of $25 each. 40,000 shares issued. $2 paid in.

Nathaniel Thayer, President.

Chas. J. Paine, Jr., Secretary and Treasurer.

These officers and Samuel N. Brown, N. H. Stone, J. Henry Brooks, Geo. P. Gardner, Walter Hunnewell and R. R. Goodell, Directors.

Fredric W. Nichols, Agent.

Controlled by St. Mary's Canal Mineral Land Co. Owns idle property northwest of Atlantic, Houghton County.

PHOENIX CONSOLIDATED COPPER CO. Hancock, Mich.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Thomas F. Cole, President.

Spencer R. Hill, Vice President.

Chas. A. Wright, Jr., Secretary and Treasurer.

These officers and Capt. Thos. Hoatson, Directors.

Controlled by Keweenaw Copper Co.

Owns a large acreage in Keweenaw County, including the old Phoenix mine. The Phoenix worked several fissure veins in the early days, but has long been idle. Later work was done on the Ashbed lode without satisfactory results. Some diamond drilling was done in 1910; but the property is now idle.

QUINCY MINING CO. 32 Broadway, New York.

Capital Stock $3,750,000 in 150,000 shares of $25 each, of which 110,000 shares have been issued.

Balance of assets Dec. 31, 1911, $972,499.31.

William R. Todd, President.

Walter P. Bliss, Vice President.

These officers and Cleveland H. Dodge, James L. Bishop, Charles J.

Devereaux, Isaac H. Meserve, William M. Belcher, John M. Longyear and Otto Kirchner, Directors.

W. A. O. Paul, Secretary and Treasurer.

Charles L. Lawton, General Manager.

Mine at Hancock, Houghton County, Mich.

The Quincy is one of the leading copper mines. Up to Dec. 31, 1910, it had produced 457,903,404 pounds of copper, which with some silver, was sold for $68,168,774.83. In the last five years there was produced 101,620,255 pounds of copper from ore yielding about 16 pounds per ton. This cost 11.30 cents per pound, and was sold for 15.45 cents. In 1910 there was produced 22,517,014 pounds of copper at a profit over all expenses of $642,693.03. The cost in 1910 was 10.48 cents per pound, and the selling price 13.20 cents. In 1911 there was produced 22,252,943 pounds copper at a cost of 10.62 cents per pound. This was sold at an average price of 12.725 cents. During 1911 there was stamped 1,382,254 tons of ore. New openings during the year were at No. 7 shaft ¾ mile; at No. 2 shaft 1½ miles; at No. 6 shaft 1¾ miles and at No. 8 shaft 1½ miles. All the shafts have been deepened and the new openings show ore of good grade. Some very good ore has been developed north of No. 8 shaft in a part of the lode which was comparatively poor near the surface.

The company began paying dividends in 1862, and at the end of 1911 has paid to shareholders a total of $19,880,000.00.

The Quincy is mining the Pewabic lodes from four shafts. The southern part of the property has been extensively worked but there still remains a large amount of ore to be taken out.

The central part of the property can be worked to great depth, and this will be the source of a large quantity of ore for many years. The north end of the property is not yet developed at all, and there is, therefore, a large area of the lode yet unexplored.

Three of the four productive shafts, No. 2, No. 7 and No. 6, have reached depths, measured on the incline, of a little over one mile. The fourth, No. 8, is nearly one mile deep. A fifth shaft, No. 9, is being sunk to connect at a depth of about 2,600 ft. with a drift north on the 20th level from No. 8 shaft. No work other than sinking is now being done at No. 9. It has reached a depth of 1,800 ft. and it is expected to connect during 1912.

While in recent years the mining has been carried on at great depths, improved facilities for mining, hoisting and crushing, have made it possible to produce the ore at a lower cost than prevailed when the workings were shallow. If the copper contents continue to be as good as at the present bottom of the mine, the lode will doubtless be worked profitably to very much greater depths. Excluding the virgin territory north of No. 8 shaft the bottom of the mine has reached an average depth on the dip of the lode of about 5,200 feet.

No. 8 shaft is being electrified for power tramming. The other deep shafts are already thus equipped.

At the stampmill much attention has been given to experiments on classifiers and it has been demonstrated that a higher percentage of the copper can be saved by more careful hydraulic classification. A new classifier is now being built.

RHODE ISLAND COPPER CO.

Formerly owned part of what is now property of the Franklin Mining Co., Houghton County.

RIDGE COPPER CO.

Formerly owned part of what is now property of the Mass Consolidated Mining Co.

ST. LOUIS COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each. Controlled by the Calumet and Hecla Mining Company.

James MacNaughton, General Manager.

Property southeast of Calumet, Houghton County.

The lands were explored by diamond drilling in 1910 and 1911. At a point 7,100 feet east of the outcrop of the Kearsarge lode, several drill holes cut an amygdaloid lode from which cores showing a good mineralization of copper were taken. From the results of the drilling it was thought that a shaft should be sunk to make more extensive explorations on this lode, which has been called the "St. Louis amygdaloid." During 1911 a three compartment inclined shaft was started. The shaft is in rock from the surface, and has reached a depth of about 200 feet. Some drifting on the lode has been done; but comparatively little is yet known of the value of the deposit.

Neither the shaft nor the drifts on the first level have opened up deposits of commercial value, but the south drift showed some fair ore.

Of the several drill holes cutting the lode five showed copper and four showed none. The No. 7 hole cut 29 ft. of lode of which 5 ft. showed copper. The No. 8 hole showed fine copper in a width of 10 ft. The No. 10 and No. 12 holes showed the lode 8 ft. wide with no copper. The No. 13 hole showed a width of 39 ft. with a good showing of copper. The No. 15 showed a width of 14 ft. with no values. The No. 16 and No. 17 holes showed a width of about 30 ft. with good values and No. 18 showed the lode 25 ft. wide with no values.

SAINT MARY'S CANAL MINERAL LAND CO. 705-199 Washington St., Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each, of which 160,000 shares have been issued.

On Dec. 31, 1910, Notes Receivable, $456,400.00; Cash on deposit, $368,-576.31; Liabilities, none.

Nathaniel Thayer, President.

Charles J. Paine and J. Henry Brooks, Vice Presidents.

Charles J. Paine, Jr., Secretary and Treasurer.

These officers and Samuel N. Brown, Albert S. Bigelow, George P. Gardner, Walter Hunnewell, Charles N. King, Nathaniel H. Stone and Thomas N. Perkins, Directors.

Arthur E. Coe, Asst. Treasurer.

Frederic W. Nichols, Resident Agent in Michigan.

Dr. Lucius L. Hubbard, Consulting Geologist.

The company owns mineral rights to 14,039 acres, and owns shares of stock in the following mining companies:

50,000 Champion; 83,905 King Philip; 20,000 Hancock Consolidated; 20,165 La Salle; 20,000 Pacific; 208 Copper Range Consolidated; 842 Winona; 80 Old Colony; 25,000 Mayflower; 2,000 Ojibway; 9,000 North Lake; 1,571 Franklin and 37,222 Houghton.

SECTION TWELVE EXPLORATION CO. Hancock, Mich.

Is a private syndicate owning lands adjoining Superior and Isle Royale. Has done some exploratory work, but did none in 1911.

SENECA MINING CO. 12 Ashburton Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each. Balance of liabilities Dec. 31, 1910, $112,952.91.

R. L. Agassiz, President.

G. A. Flagg, Secretary and Treasurer.

These officers and F. W. Hunnewell, F. L. Higginson and James MacNaughton, Directors.

A. Garceau, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mine at Ahmeek, Keweenaw County, Mich.

The company owns a large acreage on the Kearsarge lode. Development work has been done from one shaft, which on Dec. 31, 1910, was 957 feet deep. Drifting has shown some good copper ground in places, but the greater part developed is low grade.

SENTER-DUPEE DEVELOPMENT CO. Calumet, Mich.

Is a private syndicate owning lands in Keweenaw County. Has done some diamond drilling during 1911.

SHELDEN AND COLUMBIAN MINE.

Is idle property north of the Isle Royale, Houghton County.

SOUTH KEARSARGE MINE.

Is one of the producing mines on the Kearsarge lode, owned by the Osceola Consolidated Mining Co.

SOUTH LAKE MINING CO. 68 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $4.60 paid in. 60,000 shares issued.

On Dec. 31, 1910, cash on hand, $7,444.82.

John C. Watson, President.

Arthur C. Paine, Secretary and Treasurer.

These officers and Charles E. Adams, Ashley Watson and P. W. Scott, Directors.

Dr. L. L. Hubbard, consulting geologist.

Property at Greenland Junction, Ontonagon County, Michigan. 334.19 acres.

During 1909 and 1910 this company drilled several holes on the property west of the Lake Mine. The drill located four copper bearing beds, two above and two below a thick bed of ophite. The cores showed much copper, and the company has during the past year, been making preparations for shaft sinking, to develop the deposits. Where the copper was found the overburden is thick, being 272 feet in each of five holes. During the past summer, therefore, the overburden was tested at various other points to find a suitable place for a shaft. The shaft was started at a point where sand piping showed the overburden to be thin, but the shaft, tapping the supply of a nearby spring, made an extraordinary amount of water, and was abandoned. A new site has since been selected, but shaft sinking is temporarily postponed, pending the financing of the company and the selection of a permanent superintendent and engineer for the development of the property.

The exploratory work at the South Lake property has shown the Keweenaw series to be there dipping towards the south instead of to the northwest as is usually the case. It is thought that the copper bearing bed overlying the ophite is the Lake lode, and that the strata must curve from nearly north at the Lake shaft to west at the South Lake boundary. Recent developments at the Lake Mine make this appear very probable.

SOUTH RANGE MINING CO. 199 Washington St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

John W. Belches, President.

Irving J. Sturgis, Vice President.

Arthur E. Coe, Secretary and Treasurer.

These officers and John C. Watson, Henry H. Stevens and Rufus R. Goodell, Directors.

Fredric W. Nichols, Resident Agent.

Owns a large acreage of undeveloped property in Houghton and Ontonagon Counties.

SOUTH SIDE MINING CO. 14-68 Devonshire St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

John C. Watson, President.

Arthur C. Paine, Secretary and Treasurer.

These officers and Harry F. Fay, Ashley Watson and D. C. Forbes, Directors.

Fredric W. Nichols, Agent.

Owns idle property west of Houghton.

SUPERIOR COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of liabilities Dec. 31, 1911, $73,089.06.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

These officers and Francis W. Hunnewell, Francis L. Higginson and James MacNaughton, Directors.

George A. Flagg, Secretary and Treasurer.

A. J. Garceau, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

The Superior has opened up what is supposed to be the northerly extension of the Baltic lode. There are two shafts in operation. At No. 1 a large body of good ore has been partially developed, and is being mined.

The No. 2 shaft is in comparatively poor ground further southwest. The two are being connected by a drift at the 12th level. The No. 1 shaft is on Dec. 31, 1911, 1,763 ft. and No. 2 is 1,210 ft. deep.

In 1910 there was stamped 140,514 tons of ore, which yielded 3,181,041 pounds of copper, an average of 22.64 pounds per ton. The recovery was not as good as usual, as the system of milling was not specially designed for the type of ore being mined here. The production in 1911 was 162,599 tons ore yielding 3,236,233 pounds copper, an average of 19.9 pounds per ton. The copper cost 15.31 cents and the price received averaged 12.652 cents.

During 1911 attention has been directed to improving the method of mining. The hanging wall has proven very difficult to support and changes have been made so that the danger from rock falls is lessened. The lode is being developed extensively by running drifts through to the north boundary. The stoping will then be begun at the boundary and carried back towards the shaft. It is proposed to use a method in which ore instead of waste rock will be used for filling. Sorting is not successful, as the ore is not readily distinguished from waste. At the Superior, Mr. Ocha Potter has demonstrated very decidedly the advantages of a one-man piston drill, and the mine is now fully equipped with the light machines.

The company reports that on the north side of the No. 1 shaft down to the 9th level no copper has been developed north of the first fault. From the 9th to the 14th level some good ground has been found north of this fault; but none has yet been found beyond a second fault, which is about 500 ft. north of the first one. Explorations at the 12, 13 and 14th levels have resulted in the discovery of a good lode west of the lode being worked and separated from it by 45 ft. of trap. The West lode, as it is called, has proven up very encouragingly.

TAMARACK MINING CO. 12 Ashburton Place, Boston.

Capital Stock $1,500,000 in 60,000 shares of $25 each.

Balance of assets Dec. 31, 1910, $1,052,422.46.

Rodolphe L. Agassiz, President.

Quincy A. Shaw, Vice President.

George A. Flagg, Secretary and Treasurer.

These officers and Francis W. Hunnewell, Francis L. Higginson, Thomas N. Perkins and James MacNaughton, Directors.

Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mine at Calumet, Houghton County, Mich.

The Tamarack is one of the best known deep mines of the world, and was until recently a very profitable one. In the period from 1888 to 1907, the company paid $9,420,000 in dividends. The past few years have resulted in a loss to the company, owing to low copper content of the ore now being mined, and the increased cost of mining at very great depth and without good ventilation.

The mine works the underlay of the Calumet and Hecla. The chief production is from the Calumet conglomerate. The Osceola amygdaloid was worked in places, but is not now being mined.

To develop the conglomerate on Tamarack property, five vertical shafts were sunk. These have depths of 3,409 feet, 4,355 feet, 5,253 feet, 4,450 feet and 5,308.5 feet respectively. From No. 3 shaft workings, an inclined shaft started at a vertical depth of 5,223.5 feet has a further depth of 335 feet on the dip. The bottom of the No. 3 incline is therefore 5,430 ft. vertically from surface.

In 1910 there was stamped 525,554 tons of ore, which yielded 11,063,606 pounds of copper, an average of 21.1 pounds per ton. This was produced at a cost of 14.7 cents, and most of it was sold at 12.97 cents.

Owing to the unprofitable nature of operations at low copper prices, the working force has been cut down, and much of the development work suspended.

The 1911 production was 392,338 tons ore yielding 7,494,077 pounds copper at a cost of 15.56 cents. The selling price during 1911 averaged 12.71 cents. The average yield was 19.1 pounds per ton.

In November, 1911, further development work was discontinued and the amount of ore stoped was somewhat increased. The results for November and December show a cost of about 12 cents per lb. Whether or not the margin of profit will warrant further development work, must be determined by future conditions.

TAMARACK JUNIOR MINE.

Is an abandoned mine on the Calumet conglomerate, owned by the Osceola Consolidated Mining Company.

TOLTEC MINE.

An idle property at Greenland, Ontonagon County.

TORCH LAKE MINING CO. 5-19 Exchange Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Thacher Loring, President.

Chilton Cabot, Secretary.

Frederic W. Nichols, Agent.

Owns idle property east of the La Salle, Houghton County.

TREMONT AND DEVON MINING CO. Hancock, Mich.

Capital Stock $250,000 in 10,000 shares of $25 each.

Hon. Chas. Smith, President.

Fred H. Begole, Vice President.

Chas. D. Hanchette, Secretary.

These officers and Jos. Bosch, James B. Cooper, Henry L. Baer and Robt. P. Dunstan, Directors.

Owns idle lands west of Victoria, Ontonagon County.

TRIMOUNTAIN MINING CO. 82 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each $20.00 paid in. Balance of assets Dec. 31, 1911, $522,921.79.

William A. Paine, President.

Frederic Stanwood, Secretary and Treasurer.

These officers and J. R. Stanton, J. Henry Brooks, Charles A. Snow, R. T. McKeever and F. W. Denton, Directors.

F. W. Denton, General Manager.

Controlled by Copper Range Consolidated Co.

Mine at Trimountain, Houghton County, Mich.

The Trimountain is mining the Baltic lode between the Baltic and Champion mines. While it has proven a success, it has not yet made a record anything like that of its richer neighbors.

In the last five years there was hoisted and stamped 1,926,936 tons of ore, yielding 34,710,824 pounds of copper, an average of 18 pounds per ton. The copper cost 12.8 cents and was sold for 15.6 cents. In 1910 there was stamped 317,299 tons of ore, which yielded 5,694,868 pounds of copper, an average of 17.95 pounds per ton. This copper cost 12.17 cents and was sold for 12.74 cents per pound.

During 1911 very marked improvement has been found in the lower levels, and the future of the mine is very promising.

The production in 1911 was 347,885 tons yielding 6,120,417 pounds copper an average of 17.59 pounds per ton. The cost was 11.55 cents and the selling price 12.54 cents per pound.

UNION COPPER LAND AND MINING CO. 70 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Harry F. Fay, President.

Harold H. Anthony, Ezra H. Baker, Samuel Carr, Albert B. Merrill and John G. Stone, Directors.

E. J. Morrissey, Secretary and Treasurer.

J. Abner Sherman, Land Agent.

Geo. S. Goodale, Superintendent.

Owns a large acreage of mineral and timber lands. During the period between August, 1910 and September 1911 the company made a diamond drill cross section of its property included in the N. E. ¼ of Section 1, T. 56, R. 33, and the S. E. ¼ of Section 36, T. 57, R. 33. The formations included in this work have a total thickness of approximately 3,270 feet, 180 feet of which lies below, and the balance above, the Allouez conglomerate.

VICTORIA COPPER MINING CO. 60 Congress St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of assets Dec. 31, 1911, $64,044.26.

Fred H. Williams, President.

Charles D. Hanchette, Vice President.

James P. Graves, Treasurer.

These officers and Willard S. Martin and David A. Barker, Directors.

Sydney S. Millet, Secretary.

George Hooper, Superintendent.

Mine at Victoria, Ontonagon County, Mich.

The company is mining the Forrest amygdaloid lode. The ore is low grade. Operations have not yet proven profitable. The costs are, however, remarkably low and if fairly good ore is encountered good profits are to be expected. From the beginning of operations up to Dec. 31, 1910, there had been stamped 445,152 tons of ore yielding 5,353,835 pounds copper valued at $797,762.94.

In 1910 there was stamped 122,497 tons of ore, which yielded 1,164,564 pounds of copper. This cost $155,999.67 and was sold for $144,103.33. The cost per ton of ore mined is the lowest in the district. Cheap power is available at Glenn Falls on the Ontonagon river, near which the mine is located. The waterfall is used to compress air by the Taylor system, and sufficient power is obtained for all mine and mill purposes.

During part of 1910 the company was forced to curtail production on account of a scarcity of water, and would otherwise have made an even more remarkable record for low costs.

Developments during 1910 were regarded as more encouraging than they have been for some time. Considerable work has been done during 1911 at the new No. 6 shaft with fair results.

In recent work some unusually good ore has been encountered in drifting between the old and new shafts. The new shaft is 827.5 ft. deep on Dec. 31. The old shaft is bottomed at 2,089′. It is intended to connect the two shafts at the 12th level.

The production for 1911 was 1,303,331 pounds, recovered from 126,894 tons ore. The cost of mining, smelting, freight, marketing and office expense was $170,808.46, leaving a mining profit of $2,200.32. There was a further expense of $39,850.75 for interest, construction, development of water power, legal expense and cost of sinking shaft No. 6.

WHITE PINE COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each.
Controlled by Calumet and Hecla Mining Co.
Quincy A. Shaw, President.
Geo. A. Flagg, Secretary.
James MacNaughton, General Manager.
Thos. H. Wilcox, Superintendent.
Mine in Porcupine Mt. district, Ontonagon County.

The company is exploring the Nonesuch lode. The ore is native copper with some chalcocite in a grey sandstone. During the past few years the Calumet & Hecla Company has done 31,206 feet of diamond drilling on the property, and is now exploring the lode by a shaft. The results of exploration so far is considered satisfactory, good copper values being shown. The structure of the formation has been found not very regular, and the lode is not easily followed.

WILMOT MINING CO.

Capital Stock $500,000 in 20,000 shares of $25 each.
W. H. Garlick, President.
W. B. Gonchie, Secretary.
Owns idle property in Ontonagon County.

WASHINGTON COPPER MINING CO. Hancock, Mich.

Capital Stock $2,500,000 in 100,000 shares of $25 each.
Controlled by Keweenaw Copper Company.
Owns idle property at Delaware, Keweenaw County.

WEST MINNESOTA MINING CO. 14-68 Devonshire St., Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Francis H. Whitman, President.

Arthur C. Paine, Secretary.

Owns idle property in Ontonagon County.

WHEALKATE MINING CO. Houghton, Mich.

Capital Stock $50,000 in 20,000 shares of $25 each.

Nathan F. Leopold, President.

R. R. Goodell, Vice President.

Reginald C. Pryor, Secretary.

Albert F. Leopold, Treasurer.

Owns idle property in Houghton County.

WINONA COPPER CO.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of assets Dec. 31, 1911, $146,814.01.

Charles J. Paine, President.

Nathaniel H. Stone, Vice President.

These officers and George P. Gardner, Walter Hunnewell, Charles J. Paine, Jr., William A. Paine and James H. Seager, Directors.

Edward B. O'Connor, Treasurer and Secretary.

Dr. Lucius L. Hubbard, General Manager.

Mine at Winona, Houghton County, Mich. 2,320 acres.

Combined with King Philip Copper Co., in May, 1911.

The company is mining the Winona lode, which on the Winona and King Philip properties has been opened up by 6 shafts.

The Winona produced copper in the period 1902-1907, was not producing in 1908-1910, and resumed production in 1911. From the beginning of operations up to Dec. 31, 1910, there was stamped 210,716 tons of ore, which yielded 3,348,201 pounds copper. The production for 1911 was 97,445 tons ore yielding 1,275,675 lbs. copper, an average of 13.09 pounds per ton.

During the past two years a mill has been erected at the mine, and one head was started in March, 1911. The water supply is from the Sleeping River, and settling tanks have been put in, so that the water can be reused if necessary. A considerable saving in transportation of ore to the mill, will make the cost lower than in former periods of production, and the special designing of concentrating apparatus for the treatment of Winona ore only, should make a further saving. The output is from two shafts, No. 4 Winona and No. 1 King Philip. These are now (Dec. 1911) 1,460 ft. and 1,324 feet deep respectively. The remaining shafts are closed down. Production is being gradually increased and is now about 600 tons per day.

WOLVERINE COPPER MINING CO. 15 William St., New York.

Capital Stock $1,500,000 in 60,000 shares of $25 each.

Balance of assets June 30, 1911, was $673,339.62.

Jos. E. Gay, President.

J. R. Stanton, Treasurer.

J. Wheeler Hardley, Secretary.

These officers and E. B. Hinsdale and Samuel L. Smith, Directors.

Fred Smith, Agent.

Mine at Kearsarge, Houghton County, Mich.

The Wolverine is mining one of the richest parts of the Kearsarge lode, and is one of the most profitable mines in the district. In the last five years there was stamped 1,779,273 tons of ore, which yielded 48,163,660 pounds of copper, an average of 26.7 pounds per ton. This copper cost 7.65 cents and was sold for 15.6 cents per pound. In the year 1910-1911, there was stamped 388,476 tons of ore, which yielded 9,617,168 pounds of copper, an average of 24.75 pounds per ton. This copper cost 7.542 cents and was sold for 12.58 cents per pound.

The Wolverine ore body is unusually uniform in grade, and very little of the lode is left unbroken. Of the rock hoisted in the last year only 2.95% was discarded as poor. The new ground opened is of the usual grade. Mr. J. R. Finlay, for the State Tax Commission, in 1911 estimated a future output for Wolverine of 3,600,000 tons of ore, containing 80,000,000 pounds of copper. The directors consider this estimate too low, and Mr. Stanton has been reported as stating that the present output can be maintained for 15 years instead of only 10 years. Development work is well ahead of stoping, and the whole ore body will in a few years be completely developed.

The ore on the Kearsarge lode being now pretty well blocked out, more attention is being given to exploration for other lodes. Diamond drilling has been done, and a shaft sunk on the Osceola lode. At a depth of 186 feet in the No. 5 shaft, drifts were extended north and south on the hanging wall. The Osceola lode was found to be well defined and of good width, but the values were low. Drifting was then discontinued, and the shaft sunk to greater depth, and the lode tested at a second level.

Exploration has also been carried on by a cross cut driven east from the Kearsarge lode between No. 3 and No. 4 shafts at the 28th level. In July, 1911, this cross cut had been driven 1,000 feet, and it is expected that it will soon cut a series of amygdaloid beds, which were discovered by diamond drilling on the Old Colony property.

WYANDOT COPPER CO. 68 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $10 per share paid in. Balance of assets March 31, 1911, $34,091.95.

John C. Watson, President.

Charles E. Adams, Secretary and Treasurer.

These officers and Joseph Dorr, M. A. O'Neil and Frank L. Van Orden, Directors.

Frank L. Van Orden, Agent.

Mine at Winona, Houghton County, Mich.

The company has explored part of its property by shafts, cross cuts and diamond drill holes. Diamond drilling and trenching during 1910 showed a copper bearing bed which was considered promising, and a shaft was sunk to explore it further. During 1911 exploration has been carried on by driving a cross cut east from the bottom of a 700 foot shaft. The cross cut has opened up several beds, which it is proposed to test by drifting. An assessment of $1 per share has recently been called to provide funds to continue the work.

CHAPTER XII—STATISTICAL TABLES.

DIVIDENDS PAID BY MICHIGAN COPPER COMPANIES.

	Capital stock.	1907.	1908.	1909.	1910.	1911.	All years.
Ahmeek	$1,250,000					$100,000	$100,000
Atlantic	2,500,000						990,000
Baltic	2,500,000	$1,000,000	$900,000	$1,000,000	$1,000,000	500,000	7,050,000
Calumet & Hecla	2,500,000	6,500,000	2,000,000	2,700,000	2,900,000	2,400,000	114,900,000
Central							2,130,000
Champion	2,500,000	1,000,000	500,000	500,000	900,000	500,000	6,400,000
Cliff							2,518,620
Copper Falls							100,000
Franklin	5,000,000						1,240,000
Kearsarge							160,000
Minnesota							1,820,000
Mohawk	2,500,000	900,000	250,000	300,000	200,000	150,000	2,300,000
Osceola	2,500,000	1,249,950	192,300	769,200	961,500	721,125	10,064,375
Quincy	3,750,000	1,350,000	495,000	440,000	412,500	440,000	19,742,500
Tamarack	1,500,000	420,000					9,420,000
Trimountain	2,500,000						800,000
Wolverine	1,500,000	1,050,000	600,000	600,000	600,000	540,000	6,840,000

ASSESSMENTS CALLED DURING 1911.

	Per share.	Amount.
Adventure	$1 00	$100,000
Franklin	2 00	332,652
Hancock	4 00	400,000
Indiana	1 50	120,000
King Philip	1 00	100,000
Mass	2 00	200,000
Mayflower	1 00	100,000
Ojibway	2 00	168,000
Old Colony	1 00	100,000
St. Louis	2 50	100,000
Victoria	1 00	100,000
Winona	1 00	165,647
Wyandot	1 00	100,000
Total	....	$2,086,299

PRODUCTION OF COPPER IN THE UNITED STATES.
(Smelter output in pounds.)

	1907.	1908.	1909.	1910.	1911.
Alaska	7,034,763	4,438,863	4,057,142	4,311,026	22,314,889
Arizona	256,778,437	289,523,267	291,110,298	297,250,538	303,202,532
California	33,696,602	39,643,833	53,568,708	45,760,200	35,835,651
Colorado	13,998,496	13,943,878	11,485,631	9,307,497	9,791,861
Georgia (a) Maryland and Alabama	(a)90,655	....	....	724	(a)23,555
Idaho	9,707,299	7,256,086	7,096,132	6,877,515	4,514,116
Michigan	219,131,503	222,289,584	227,005,923	221,462,984	218,185,236
Montana	224,263,789	252,503,651	314,858,291	283,078,423	271,814,491
Nevada	1,998,164	12,241,372	53,849,281	64,494,640	65,561,015
New Hampshire	....	135,139	88,944	12,409	....
New Mexico	10,140,140	4,991,351	5,031,136	3,784,609	2,860,400
North Carolina	544,040	29,391	120,451	181,263	13,699
Oregon	518,694	271,191	245,403	22,022	125,943
Pennsylvania	....	....	994,089	740,626	661,621
Philippine Islands	....	....	....	1,781	9,612
South Dakota (b) includes Maryland, Alabama, South Carolina and Texas	....	(b)30,488	41,988	43	1,607
Tennessee	19,745,119	19,710,103	19,207,747	16,691,777	18,965,143
Texas	....	....	3,456	2,961	105
Utah	66,418,370	71,370,370	101,241,114	125,185,455	142,340,215
Vermont	696,102	....	....	1,935	....
Virginia	57,008	25,087	231,971	105,313	....
Washington	122,263	162,201	120,611	65,021	195,503
Wyoming	3,026,004	2,416,197	433,672	217,127	130,499
Missouri and unapportioned (c) and other states	1,299,043	1,580,831	2,159,636	603,570	685,056
	868,996,491	942,570,721	1,092,951,624	1,080,159,509	1,097,232,749

These figures for 1907-1911 are from U. S. G. S. reports.

PRODUCTION OF MICHIGAN COPPER MINES IN RECENT YEARS.
(Pounds Avoirdupois.)

	1906.	1907.	1908.	1909.	1910.	1911.
Adventure	1,552,628	1,244,874	90,870			
Ahmeek	3,077,507	5,510,985	6,280,241	9,198,110	11,844,954	15,196,127
Allouez	3,486,900	2,934,116	3,047,051	4,031,532	4,655,702	4,780,494
Atlantic	1,439,082					
Baltic	14,397,557	16,704,868	17,724,854	17,817,836	17,549,762	15,370,449
Calumet and Hecla	100,023,420	83,863,116	82,549,979	80,096,995	72,059,545	74,130,977
Centennial	2,253,015	2,373,572	2,196,377	2,583,793	1,572,566	1,493,834
Champion	16,954,986	16,489,436	17,786,763	18,005,071	19,224,174	15,639,426
Franklin	4,571,570	4,401,248	3,707,518	1,615,556	966,353	820,203
7—Hancock						754,729
Isle Royale	2,937,098	2,667,608	3,011,664	5,719,056	7,567,339	7,490,120
Keweenaw			122,474	57,091	36,682	
7—LaSalle					633,778	280,598
Lake					318,050	
Mass	2,106,739	2,078,677	1,766,930	1,723,436	1,321,885	1,326,898
Michigan	2,875,341	2,665,404	3,000,206	1,979,305		327,773
Mohawk	9,352,252	10,107,266	10,295,881	11,248,474	11,412,066	12,091,056
Osceola	18,588,451	14,134,753	21,250,794	25,296,657	19,346,566	18,388,193
Quincy	16,194,838	19,796,058	20,600,361	22,511,984	22,517,014	22,252,943
Superior			21,244	1,781,315	3,181,041	3,236,233
Tamarack	9,832,644	11,078,604	12,806,127	13,533,207	11,063,606	7,494,077
Trimountain	9,507,933	8,190,711	6,034,908	5,282,404	5,694,868	6,120,417
Victoria	546,334	1,207,237	1,290,040	1,062,218	1,164,564	1,303,331
Winona	278,182	1,285,863				1,275,675
Wolverine	9,548,123	9,272,351	9,955,233	9,971,482	9,666,534	
Gratiot					265,869	14,275
Ojibway						
Totals (U. S. G. S. figures, including products of some other mines). (Smelter returns)	229,695,730	219,131,503	222,289,584	227,005,923	221,462,984	219,840,201
Value copper	$43,791,600	$43,553,446	$29,473,844	$30,437,749	$28,280,800	
Value silver	148,889	197,844	127,759	148,944	178,470	
Total	$43,940,489	$43,751,290	$29,601,603	$30,586,693	$28,459,270	

Most of these figures are from reports of the Mining companies. The remainder are the best obtainable from other sources.

SUMMARY OF RESULTS OBTAINED IN 1908, 1909, 1910 AND 1911 BY THE OUTPUT OF

	Tons of ore stamped.	Per ton of ore. Cost of mining, transportation, stamping and taxes.	Pounds of mineral obtained.	Pounds of refined copper produced.
1. C. & H. All ore........1911	2,909,972	1.84	....	74,130,977
1910	2,795,514	1.92	....	72,059,545
1909	2,842,880	1.93	....	80,095,995
1908	2,643,938	2.15	....	82,549,979
2. C. & H. Conglomerate 1911	1,924,480	2.07	....	58,469,399
1910	1,950,040	2.11	....	58,739,509
1909	1,999,880	2.11	....	66,285,684
1908	1,958,200	2.25	....	70,427,877
3. Tamarack............1911	392,338	2.69	12,793,430	7,494,077
1910	525,554	2.67	22,053,480	11,063,606
1909	689,099	2.44	20,286,174	13,533,207
1908	654,894	2.57	19,134,429	12,806,127
4. C. & H. Amygdaloid ..1911	985,492	1.34	....	15,661,578
1910	831,194	1.41	....	13,150,427
1909	838,200	1.42	....	13,752,276
1908	685,738	1.75	....	12,122,102
5. Osceola.............1911	1,246,596	1.14	24,452,912	18,388,193
1910	1,217,720	1.28	25,669,913	19,346,566
1909	1,494,845	1.36	33,107,579	25,296,657
1908	1,241,400	1.45	26,912,944	21,250,794
6. Ahmeek 1911	598,549	1.42	21,917,925	15,196,127
1910	530,365	1.42	16,758,521	11,844,954
1909	406,045	1.72	12,409,042	9,198,110
1908	298,178	1.78	8,029,960	6,280,241
7. Allouez..............1911	288,610	1.668	7,532,490	4,780,494
1910	247,119	1.769	7,406,970	4,655,702
1909	253,049	1.806	6,384,450	4,031,532
1908	220,905	2.051	4,716,105	3,047,051
8. Wolverine.......1911–1912	....	....	....	....
1910–1911	388,476	1.64	12,227,500	9,617,168
1909–1910	390,837	1.61	12,359,000	9,757,101
1908–1909	394,433	1.60	12,692,610	9,995,748
9. Mohawk.............1911	802,548	1.406	15,760,700	12,091,056
1910	902,537	1.43	15,013,500	11,412,066
1909	819,019	1.40	14,690,200	11,248,474
1908	685,823	1.44	13,310,820	10,295,881
10. Centennial 1911	86,543	1.869	2,321,200	1,493,834
1910	101,133	1.9477	2,380,566	1,572,566
1909	196,525	1.818	3,941,820	2,583,193
1908	169,693	2.086	3,352,790	2,196,377
11. Baltic 1911	696,795	1.714	25,254,160	15,370,449
1910	781,419	1.67	28,067,300	17,549,762
1909	814,260	1.55	27,421,000	17,817,836
1908	764,117	1.56	25,282,145	17,724,854
12. Champion............1911	734,392	1.743	26,137,007	15,639,426
1910	722,051	1.86	30,508,690	19,224,174
1909	753,908	1.80	27,851,720	18,005,071
1908	794,703	1.62	26,579,795	17,786,763
13. Trimountain 1911	347,885	1.819	10,705,685	6,120,417
1910	317,299	2.00	9,598,900	5,694,868
1909	323,408	2.09	9,118,095	5,282,404
1908	334,929	2.05	9,634,979	6,034,908

18 COPPER MINES WHICH PRODUCED OVER 99 PER CENT OF THE TOTAL MICHIGAN.

Per cent refined copper in mineral.	Pounds of refined copper per ton of ore stamped.	Cost per pound at mine excluding construction.	Cost per pound construction.	Other costs per pound.	Cost per pound smelting, freight commission eastern office.	Cost per pound interest paid.	Total cost per pound, copper.	Price received for copper sold.
....	25.47	....	....	....	....	....	8.52	12.82
....	25.77	....	....	....	....	....	8.96	13.20
....	28.18	....	....	....	....	....	8.28	13.61
....	31.22	....	....	....	....	....	9.00	13.62
....	30.38	....	....	....	....	....	8.25	12.82
....	30.12	....	....	....	....	....	8.55	13.20
....	33.14	....	....	....	....	....	7.77	13.61
....	35.96	....	....	....	....	....	8.38	13.62
58.58	19.1	14.07	0.06	....	1.23	0.20	15.56	12.71
50.17	21.1	12.66	0.57	....	1.30	0.17	14.70	12.97
66.71	19.6	12.41	0.33	....	1.18	0.38	14.30	13.32
66.93	19.6	13.14	0.64	....	1.36	0.10	15.24	13.39
....	15.89	....	....	....	....	....	9.95	12.82
....	15.82	....	....	....	....	....	10.53	13.20
....	16.40	....	....	....	....	....	10.41	13.61
....	17.67	....	....	....	....	....	12.25	13.62
75.198	14.8	7.73	0.49	....	1.06	....	9.28	12.72
75.367	15.9	8.04	0.35	....	0.98	....	9.37	13.04
76.407	16.9	8.04	0.44	....	0.99	....	9.47	13.30
78.961	17.1	8.25	0.69	....	1.10	....	10.25	13.39
69.33	25.4	5.61	0.32	....	1.19	0.05	7.17	12.78
70.68	22.3	6.37	1.85	1.56	1.16	0.11	11.05	12.99
74.12	22.7	7.61	5.27	1.47	1.10	0.03	15.48	13.37
78.21	21.1	8.64	2.40	0.51	1.11	0.00	12.66	13.46
63.47	16.56	10.07	0.90	....	1.95	0.38	13.30	12.822
62.86	18.84	9.39	0.00	....	1.81	0.37	11.57	12.68
63.14	15.93	11.34	0.21	....	1.51	0.33	13.39	13.26
64.61	13.80	14.86	0.22	....	1.40	0.33	16.81	13.35
....	....	....	....	....	....	....	....	....
78.65	24.75	6.628	0.023	....	0.891	....	7.542	12.58
78.947	24.96	6.453	0.03	....	0.93	....	7.413	13.24
....	26.75	6.002	0.45	....	0.923	....	7.375	13.35
76.71	15.07	9.33	0.259	....	0.81	....	10.399	12.63
76.01	14.22	10.076	0.48	....	.889	....	11.44	13.09
76.57	13.73	10.22	0.01	....	.875	....	11.21	13.20
77.35	15.01	9.60	0.21	....	.938	....	10.75	13.43
64.36	17.26	10.83	0.00	....	1.43	0.43	12.69	12.842
66.05	15.40	12.65	0.00	....	1.49	0.34	14.48	13.12
65.55	13.15	13.82	0.08	....	1.56	0.15	15.61	13.28
65.51	12.94	16.12	0.74	....	1.63	....	18.49	13.39
....	22.06	....	....	....	....	....	9.09	12.54
....	22.46	....	....	....	....	....	8.32	12.74
....	21.88	....	....	....	....	....	7.98	13.00
....	23.20	....	....	....	....	....	7.72	13.39
....	21.296	....	....	....	....	....	9.63	12.54
....	26.62	....	....	....	....	....	7.85	12.74
....	23.88	....	....	....	....	....	8.45	13.00
....	22.38	....	....	....	....	....	8.34	13.39
....	17.59	....	....	....	....	....	11.55	12.54
....	17.95	....	....	....	....	....	12.17	12.74
....	16.33	....	....	....	....	....	13.89	13.00
....	18.02	....	....	....	....	....	12.5	13.39

SUMMARY OF RESULTS OBTAINED

		Tons of ore stamped.	Per ton of ore. Cost of mining, transportation, stamping and taxes.	Pounds of mineral obtained.	Pounds of refined copper produced.
14. Superior	1911	162,599	2.39	....	3,236,233
	1910	140,514	2.69	....	3,181,041
	1909	81,641	....	....	1,781,315
	1908	962	....	....	21,244
15. Quincy	1911	1,382,254	....	32,550,440	22,252,943
	1910	....	....	34,177,380	22,517,014
	1909	....	....	35,025,225	22,511,984
	1908	....	....	32,754,745	20,600,361
16. Franklin	1911	....	....	....	820,203
	1910	113,859	....	....	966,353
	1909	170,456	1.94	3,306,820	1,615,556
	1908	....	....	....	....
17. Isle Royale	1911	457,440	1.42	10,339,171	7,490,120
	1910	520,860	1.42	10,433,060	7,567,399
	1909	401,280	1.87	7,926,015	5,719,056
	1908	218,940	2.33	4,013,590	3,011,664
18. Victoria	1911	126,894	....	2,128,245	1,303,331
	1910	122,497	....	1,923,599	1,164,564
	1909	118,605	....	1,843,152	1,062,218
	1908	109,015	1.51	2,259,928	1,290,040
19. Mass	1911	73,475	....	1,949,720	1,326,898
	1910	90,747	....	1,790,795	1,321,885
	1909	139,404	....	....	....
	1908	171,268	....	....	....
20. Michigan Mine	1911	....	....	....	327,773
	1910	....	....	....	....
	1909	148,172	....	2,457,346 Mass. 485,846	1,979,305
	1908	190,331	....	3,270,250 Mass. 1,226,845	3,000,206
Total production (from U. S. G. S. Reports).	1911	10,978,827	....	....	219,840,201
	1910	10,869,561	....	360,840,547	222,683,461
	1909	11,429,394	....	358,862,935	234,136,529
	1908	10,531,271	....	339,233,252	223,286,700

IN 1908, 1909 AND 1910.—CONCLUDED.

Per cent refined copper in mineral.	Pounds of refined copper per ton of ore stamped.	Cost per pound at mine excluding construction.	Cost per pound construction.	Other costs per pound.	Cost per pound smelting, freight commission eastern office.	Cost per pound interest paid.	Total cost per pound, copper.	Price received for copper sold.
....	19.90	12.01	0.89	....	2.02	0.39	15.31	12.652
....	22.64	....	....	....	....	....	14.29	12.63
....	21.82	....	....	....	....	....	....	13.56
....	22.08	....	....	....	....	....	....	....
68.4	16.1	9.25	0.48	....	0.89	....	10.62	12.725
65.88	....	8.80	0.50	0.25	0.93	....	10.48	13.20
64.27	....	8.85	0.50	0.26	0.91	....	10.52	13.40
60.28	....	9.615	0.58	0.23	0.85	....	11.27	13.57
....	....	....	....	....	....	....	....	12.516
....	....	....	....	....	....	....	....	13.33
....	9.47	....	....	....	....	....	....	
....	....	....	....	....	....	....	....	....
72.44	16.4	8.97	0.25	0.13	1.21	0.29	10.85	12.38
72.53	14.5	9.75	0.16	0.33	1.26	0.34	11.84	12.68
72.16	14.3	13.12	1.28	0.55	1.44	0.25	16.64	13.00
75.04	13.8	16.91	9.65	0.44	1.99	0.00	28.99	13.29
....	10.3	....	....	....	....	....	....	....
....	....	....	....	....	....	....	13.4	12.3
....	11.18	12.366	....	....	1.97	....	14.335	13.10
68.055	17.58	....	....	....	....	....	....	12.50
73.837	14.59	....	....	....	....	....	....	....
....	12.36	....	....	....	....	....	....	....
....	10.31	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	13.16
....	....	....	....	....	....	....	....	13.305
....	20.0	....	....	....	....	....	....	....
61.71	20.5	....	....	....	....	....	....	13.00
65.24	20.5	....	....	....	....	....	....	12.7
65.82	21.2	....	....	....	....	....	....	13.2

SUMMARY OF RESULTS

	Tons of ore stamped.	Cost of mining, transportation and stamping, per ton, ore	Pounds of concentrate obtained.	Pounds of refined copper produced.
Ahmeek	598,549	$1.42	21,917,925	15,196,127
Allouez	288,610	1.668	7,532,490	4,780,494
Baltic	696,795	1.714	....	15,370,449
C. & H	....	....	....	....
C. & H. Conglomerate	....	....	....	....
C. & H. Amygdaloid	....	....	....	....
Centennial	86,543	1.869	2,321,200	1,493,834
Champion	734,392	1.743	....	15,639,426
Franklin	....	....	....	820,203
Hancock	41,449	....	....	754,749
Isle Royale	457,440	1.42	10,339,171	7,490,120
Mass	73,475	....	1,949,720	1,326,898
Michigan	....	....	....	....
Mohawk	802,548	1.406	15,760,700	12,091,056
Osceola	1,246,596	1.14	24,452,912	18,388,193
Quincy	1,382,254	....	32,550,440	22,252,943
Superior	162,599	2.39	....	3,236,233
Tamarack	392,338	2.69	12,793,430	7,494,077
Trimountain	347,885	1.819	....	6,120,417
Victoria	126,894	....	2,128,245	1,303,331
Winona	97,445	....	2,533,870	1,275,675
Wolverine	....	....	....	....

OBTAINED IN 1911.

Per cent of refined copper in concentrate.	Pounds refined copper per ton of ore stamped.	Cost per pound at mine excluding construction.	Cost construction.	Cost per pound smelting, freight commission eastern office.	Other costs.	Cost per pound interest paid.	Total cost per pound, copper produced.	Price received for copper sold.
69.33	25.4	5.61	0.32	1.19	....	0.05	7.17	12.78
63.47	16.56	10.07	0.90	1.95	....	0.38	13.30	12.822
....	22.06	....	....	....	....	....	9.09	12.54
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
64.36	17.26	10.83	0.00	1.43	....	0.43	12.69	12.842
....	21.296	....	....	....	....	....	9.63	12.54
....	....	....	....	....	....	....	....	12.516
....	18.21	....	....	....	....	....	....	....
72.44	16.4	8.97	0.25	1.21	0.13	0.29	10.85	12.38
68.055	17.58	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
76.71	15.07	9.33	0.259	0.81	....	....	10.399	12.63
75.198	14.8	7.73	0.49	1.06	....	....	9.28	12.72
68.4	16.1	9.25	0.48	0.89	....	....	10.62	12.725
....	19.90	12.01	0.89	2.02	....	0.39	15.31	12.652
58.58	19.1	14.07	0.06	1.23	....	0.20	15.56	12.71
....	17.59	....	....	....	....	....	11.55	12.54
....	10.3	....	....	....	....	....	....	....
....	13.09	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....

THE IRON MINING INDUSTRY OF MICHIGAN.

BY R. C. ALLEN.

CONTENTS.

CHAPTER I.

IMPORTANCE OF THE INDUSTRY.

For nearly a half century prior to 1901 Michigan held first place in production of iron ore. In this year and annually to the present time the production from the great Mesabi range of Minnesota has over-shadowed the production of all other iron ranges and this range is now sending out more than two-thirds of the tonnage annually mined in the entire Lake Superior region and one-half of the total production of the United States. Notwithstanding the overwhelming magnitude of the Mesabi range production in recent years Michigan at the close of 1910 had shipped nearly half (221,122,495 tons) of the total tonnage mined in the Lake Superior region and about one-fourth of the entire tonnage mined in the United States in all preceding time. If these comparisons were expressed in weight of metallic iron Michigan's proportion of the total would be still greater.

PERMANENCY OF THE IRON MINING INDUSTRY.

The backward view is eminently satisfactory but what of the future? A recent estimate (1911) by J. R. Finlay for the Michigan State Tax Commission, places the Michigan iron ore reserves in sight at 196,354,883 tons, an amount which is almost equal to the total shipments to 1911. This estimate does not include low grade material which will be salable at some future time, but iron ore of salable grade under 1911 conditions. This estimate supports the contention that shipments are on the average annually exceeded by developed new tonnage to the end that reserves increase more rapidly then shipments. There is no good reason to believe that reverse conditions will begin to operate in Michigan in the immediate future. Michigan's supply of iron ore is of course exhaustible, but relatively the supply is a permanent one. No one, no matter what completeness of information he may have at his command, would care to set the date when iron mining on a large scale in Michigan will cease. There is more high grade ore in sight today than ever before, almost as much as has been extracted in some sixty-five years of continuous mining. The low grade ores have not been touched. Of these the supply is enormous. In our present state of knowledge it is quite useless to speculate on the grand total of available iron ore. All that can be said is that the end of iron mining in Michigan is so far removed that speculations regarding the date of its appearance have no present value or interest.

THE MICHIGAN IRON FORMATIONS.

The names of the copper bearing and iron bearing formations and their age relationships are given below.

Algonkian	Keweenawan. Copper on Kewenaw Point and in Ontonagon Co. Series.	
	Huronian Series	Upper—Iron in Ironwood formation of the Gogebic range. Iron in Vulcan formation of Iron River. Crystal Falls, and Menominee districts, and Bi iki iron bearing member of Marquette and Gwinn districts.
		Middle—Iron in Negaunee formation of Marquette and Gwinn districts.
		Lower—.
Archean	Keewatin Series. Iron bearing formations reported near Marenisco.	
	Laurentian Series.	

The entire iron ore production of Michigan has come from the Upper and Middle Huronian series. The Middle Huronian is not known in the Lake Superior region outside of Michigan and is productive only in the Negaunee formation of the Marquette district. It has produced over forty per cent of the total output of the state.

Character of the Iron Formations: The iron formations, in which the iron ore bodies are found are sedimentary rocks composed, in an altered condition, chiefly of silica in the form of chert and quartz, and the iron bearing minerals, ferrous carbonate (siderite), ferrous silicate (greenalite) and iron oxide (mainly hematite). Oxidation has transformed most of the ferrous iron contents to iron oxide in the exposed parts of the formations producing *ferruginous cherts* ("soft ore jasper") *ferrouginous slates* and by further metamorphism (anamorphism) *jaspilites* ("hard ore jasper"). If oxidation is complete and the silica content sufficiently reduced by leaching, ore bodies result.

Relations to Other Formations: The iron formations are interbedded with other sedimentary rocks such as slate, quartzite and dolomite and in some places with igneous rocks of volcanic origin. In some areas they are cut by dikes and irregular masses of younger intrusive igneous rocks, notably in the Gogebic and Marquette districts.

Thickness of the Iron Formations: The iron bearing beds vary greatly in thickness in the different iron ranges. In the Gogebic district the maximum thickness is 800 to 1,000 feet, in the Marquette district from 1,000 to possibly 1,500 feet in the Iron River and Crystal Falls districts not more than 350 feet to 400 feet, and in the Menominee district the combined thickness of the two productive beds varies on the average between 300 feet and 400 feet.

Deformation and Alteration of the Iron Formation: These rocks were deposited in about flat lying or horizontal position and were subsequently folded by compressive earth movements into synclines (troughs) and anticlines (arches). During deformation the iron formations were not only folded but fractured, and along many of these fractures faults or displacements occurred. Deformation was mainly accomplished while the iron bearing beds were buried beneath overlying formations but erosion has since removed the overlying rocks in those areas where the iron formations are now exposed at the surface.

Formation of the ore bodies: The ore bodies are concentrations of iron oxide in exposed parts of the richer layers of the iron formation. They are further very largely limited in occurrence to places where structural conditions combine with other factors to render the agents of alteration exceptionally effective. The main agent of alteration is oxygenated and carbonated meteoric water. The waters descend from the surface oxidizing the ferrous carbonate and silicate to ferric oxide and leaching out the silica. Those parts of the iron formation most happily situated to receive a vigorous circulation of oxidized and carbonated waters are more apt to carry ore bodies than parts not so situated. Concentration of downward moving meteoric waters is favorably influenced by certain structural conditions such as (1) the occurrence of impervious foot walls of slate or other rocks, (2) pitching troughs with impervious basements, (3) an inclined position of the iron formation, (4) a brecciated or porous condition of the iron formation, (5) a large area of the iron formation exposed at the surface.

Ferruginous chert and ferruginous slate are iron formation rocks which represent a part way stage between the unaltered phase and iron ore. In them the original ferrous carbonate and ferrous silicate minerals are partly or wholly oxidized to ferric oxide but the silica has not been removed. Rocks thus altered make up the great bulk of the iron formation.

Depth to which Iron Ore Occurs: Nearly all of the ore bodies are exposed at the rock surface. Those deposits which are not exposed at the rock surface are connected with this surface by ferruginous chert or slate, that is to say, by rocks which have been altered by processes which if completed would result in ore concentration. Ore deposits may be expected to occur to depths to which an active circulation of oxidizing waters has penetrated. Obviously such depths will depend on factors of uncertain character which vary widely in different localities. For these reasons speculation as to the maximum depth at which ore will ultimately be found is hazardous to say the least. The Newport mine at Ironwood has developed a large body of high grade ore under 2,000 feet in depth. A greater depth (2,200 feet) is attained by the ores of the Champion mine in the Marquette district. Other mines are approaching this depth. Deep drilling is meeting with encouraging results in many explorations. The ultimate maximum depth at which iron ores may be found and from which they may be profitably mined has not been attained.

THE CHARACTER OF MICHIGAN IRON ORES.

The great bulk of Michigan iron ore is hematite with some limonite and a small amount of magnetite. In statistical tables nearly all Michigan ores are graded as hematite. The textures vary from soft, granular, and powdery to hard, specular, and schistose. The lowest grade of ore shipped from Michigan mines has averaged about 40% metallic iron. The annual shipments from Michigan mines vary mainly between 50% and 60% metallic iron. For the chemical composition of Michigan ores for 1910 see statistical tables.

CHAPTER II.

IMPORTANT FEATURES OF THE IRON MINING INDUSTRY.

The Geological Survey is often asked for information relative to particular features of the iron mining industry. Naturally, these inquiries come not so frequently from those connected with the industry as from other sources, including land owners, legislators, publishers, etc., both in and out of the state. In the following pages is discussed in an elementary way some of the more important factors in the business of mining and marketing iron ore, including (1) exploration, (2) royalties, values and ownerships, (3) prices and price determinations, (4) sampling and analyses, and (5) transportation.

EXPLORATION FOR IRON ORE.

In the early days on the Michigan ranges prospecting was confined to a search for exposures of iron ore. It was not long in the early history of each range before the more promising exposures of ores were located and thereafter further discoveries resulted only from underground exploration, either projected from the workings of the mines or conducted in new ground by test pitting and drilling. In order to eliminate barren ground it was found advantageous to indicate on maps or plats the known occurrences of iron formation, thus initiating the construction of geological maps. The early prospectors were beset with the difficulties inherent in a wooded country with few or no roads. Furthermore they had to deal with complex geological structures of the rocks, and did not have the aid furnished to the modern explorer through the publication of geologic maps and volumes of literature, the product of many years of experience and study by miners, geologists and engineers. In fact the oft repeated sayings of the Cornish miner "*where* it is *there* it is," and "where there is *some* there is *more*," well illustrate the status of knowledge of the early explorers for iron ore.

Through study and experience the geologic structure of the rocks and the conditions of ore occurrences became increasingly better understood and has had its effect in better and more intelligently directed exploration. With the discovery of each successive new range there has, however, always been a tendency for the explorer to assume that geologic conditions on the new range were analagous to those on the older range with which he was more particularly familiar. These assumptions, when strongly held, have proven more of a handicap than a help for the different ranges are unlike in succession and structure of the rocks and the most successful methods of exploration take this fact into account. The inability to quickly apprehend new or modified conditions and to meet them with a corresponding change in procedure in exploration, i. e., and inelasticity of thought and method, is less common among explorers now than it was a few years ago.

The methods of modern exploration for iron ore may best be illustrated by an outline of procedure in a suppositious case. Suppose a mining company feels the need of increasing its ore reserves by exploration in new territory. This is the condition generally obtaining in Michigan for the strength of a mining company and its continued existence depend on the opening of new reserves to take place of those which become exhausted. Those companies which are both miners and steel and iron makers find it expedient not only to maintain a large reserve of minable ore but reserves of different grades of ore for use in properly mixing furnace charges.

It may be taken for granted that the company is able to use discriminating judgment in selection of lands to explore. The larger companies maintain a force of engineers and geologists whose business it is to keep well abreast of the developments in geology and mining throughout the ranges in which the company operates.

If the lands which it is desired to explore are not owned by the company they may be obtained (1) by purchase or (2) by lease. Transfers to title of minerals in iron bearing lands on developed Michigan ranges are not common, the owners preferring to retain title as a source of income under lease. An option to explore with privilege of lease at or before the expiration of the option is practically always preliminary to a lease on undeveloped lands. The terms of the option vary, but usually contain the following major stipulations: (1) The mining company is given a certain stated length of time to explore. The owner may demand and in some cases receive a cash bonus for the option, the amount of which is conditioned on the strength of the probability of ore occurrence, etc., and may, under certain conditions, agree to an extension of the option period on request of the company. The option commonly obligates the company to make a stated minimum expenditure for exploration, to do a certain number of feet of drilling or to work continuously during the life of the option. (2) The terms of lease which may be exercised or rejected by the company are stated in the option. They include (a) stipulation of the *royalty*. The fee owner usually receives a *minimum royalty* which is a lump sum to be paid annually for the privilege of holding the lease and a per ton royalty on shipments from the property. The amount of the latter varies in different districts and localities and for different grades of ore. It may be a flat or a graded rate per ton, a certain percentage of the sale price, or under certain conditions a minimum flat or graded rate plus a premium based on the sale price. The per ton royalties are usually credited against the minimum royalties and if the former totals less than the minimum, the difference is paid. (b) The company exercising lease is usually obligated to pay taxes. (c) In lieu of a low minimum royalty there is sometimes a provision for continuous operation of the property. Under a low minimum royalty a company may find it expedient not to operate but to hold the ore in reserve. Many other items which are not here considered are included in the average lease.

Having settled the terms of the option and lease the company is ready to begin exploration. The property is surveyed, sometimes both topographically and geologically, and the engineers correlate all available geologic data having a bearing on the method to be followed. The first holes are "spotted" and the drilling begins.

The business of *mining* and *exploration* have in recent years become differentiated. With the increasing use of the drill companies have been formed who conduct purely a drilling business. There are something like 400 drills in more or less continuous operation in the Lake Superior country giving employment to about 1,400 to 1,500 men. Some of these companies are large operators and employ well trained engineers and geologists to conduct the exploratory operations. These companies are equipped to handle not only the mechanical but the scientific work of exploration charging only the "going" rates for drilling but using their superior organizations as a main factor in competition for business. In most cases the mining companies desire to handle the scientific end of the exploratory work but there are increasing instances of the assumption under contract by the drilling company of the full responsibility of conducting thorough and adequate exploration as great importance attaches to the results of drilling operations, the business demands in its employ men of the highest integrity.

We may suppose that the company in this case contracts with a drilling concern for a certain minimum number of feet of drilling. For vertical holes the churn drill may be used but in any case it will be less satisfactory than the diamond drill. The latter preserves a core of rock which is useful to the engineer or geologist in charge for determining structure and succession of the strata which has a most important bearing on the location of ore bodies. Great care is used to obtain and preserve the drill cores. During the progress of drilling the samples are carefully examined and identified. Each hole is platted, often in such a way that it may be considered with others in three dimensions. Geologic sections are drawn from the acquired data and used to determine position and angle of successive holes. If ore is encountered both core and sludge are sampled for determination of iron and phosphorous content.

After the ore has been found drilling continues until something is known regarding the size, shape and quality of the deposit. The subsequent initial expenditure for mine equipment is determined most largely by the character of this information.

In general the deposits in Michigan ranges are of a shape and structure so complex that the drilling must be supplemented by underground work. Relatively little drilling is done on the Gogebic range where the portion of the iron formation at the surface is accurately known. On the other hand in drift covered areas of complex structure like the Iron River district, the iron formation must first be located by the drill preliminary to its exploration for ore deposits. Where exploration by drilling is attempted on land under option the results are usually sufficient to determine the advisability of exercising or abandoning the lease. However, there are many producing mines on lands that have been repeatedly explored and abandoned by different concerns, which serves to illustrate the fact that conditions are often such as to baffle the skill of the best equipped explorers. The element of luck still plays an important role in exploratory operations. There are comparatively few iron ore deposits in Michigan whose character and size were fully predetermined by drilling. On the Mesabi range of Minnesota the reverse is probably true.

In the case under consideration we may suppose that the results of the drilling are sufficiently encouraging to justify the exercise of the lease. The next step is the sinking of a shaft and the cutting of underground openings, involving installation of pumping and hoisting machinery. At every step the structure of the iron formation and ore body is studied and platted until the probable size and character of the deposit is disclosed. When this information is completed or well advanced the plan of the mine is laid out and the mining methods best adapted to the conditions is determined by competent engineers. The mine is now rapidly brought to the producing stage. In most cases it is necessary to continue exploration throughout the life of the mine for in perhaps the majority of Michigan iron mines the conditions found on opening one level do not necessarily imply that the same or similar conditions will be found on other levels. The cost of exploration forms a continuous, though fluctuating charge against the cost of the ore.

ROYALTIES.

The term *royalty* refers to payment by mining companies for the ore in properties which they operate but in which they own a part or none of the mineral values. The royalty is paid per ton of ore shipped and may be a flat or a graded rate or a combination of the two. The sum paid for the privilege of holding the lease is called the *minimum royalty*. The per ton royalty is commonly charged against the minimum.

It may occasion surprise to many to learn that more than three quarters of the Michigan iron mines are not owned by the operating companies. For the producing mines in the period 1906-1910 inclusive the figure is 78+%. If the Marquette range is excluded the percentage is 95 which about represents the present status of this factor in the iron mining business. The fees in most of the non royalty paying mines on the Marquette range were acquired long ago. There are few recent transfers of title to mineral fees in undeveloped iron range lands mainly because of the uncertainty of values. Both owners and miners prefer to deal with these lands under the leasing system.

Royalties which were actually paid by Michigan mines in 1905-1910 range from 82 cents to 5 cents per ton. The highest average per ton royalties are paid on the Gogebic range, then follows in decreasing order the Marquette, Gwinn, Crystal Falls, Menominee, and Iron River districts.

ROYALTIES PAID BY MICHIGAN IRON MINES, 1906-1910, INCLUSIVE.[1]

Range.	No. of mines producing in 1906-1911.	No. of shipping mines paying royalties.	Average royalties 1906-1911.			
			High.	Low.	Average per mine.	Average per ton.
Gogebic	14	12	$0.82	$0.226	$0.405	$0.388
Iron River	11	11	.62	.11	.2107	.209
Crystal Falls	14	13	.50	.13	.268	.262
Menominee, including Metropolitan and Calumet	12	12	.38	.05	.211	.242
Marquette	27	12	.57	.10	.2864	.331
Gwinn	4	4	.57	.20	.307	.323
	82	64				

[1]Compiled from "Appraisal of the Mining Properties of Michigan" by J. R. Finlay. Report of the Board of State Tax Commissioners, 1911.

VALUES.

The royalty is the *sale price* of a ton of ore in the ground and is therefore in a sense the value of the unmined ore. Royalties are usually stipulated in options to explore with privilege of lease in undeveloped land in advance of the actual exploration. The results of the exploration determines whether the ore was sold by the owner at a high or low price. J. R. Finlay determined the average value of developed but unmined Michigan ore at 61 cents per ton in 1911. This is about double the average royalty for the whole state.

There is given below a summary statement of the ore reserves, total value, and equalized assessed value, for the state for 1911 compared with Minnesota for 1910. The approximate value per ton of Michigan iron ore in stock by years at the mines is given in a later table.

	Total reserves (gross tons).	Assessed equalized value.	Total value.	Total value per ton.	Assessed value per ton.
Minnesota [2], 1910	1,347,596,291	$220,423,038	....	....	$0.163
Michigan [3], 1911	196,354,883	93,933,629	$119,485,000	$0.61	0.473

[2]By Minnesota State Tax Commission.
[3]By Michigan State Tax Commission.

OWNERSHIPS.

It has been stated above that the *titles* to ore reserves are for the most part not vested in the operating companies. The mining business including *control* of ore reserves is, however, in the hands of the operating companies. In the period 1906-1911, 82 mines controlled by 34 operating companies including subsidiaries made shipments. The Oliver Iron Mining Co. of the U. S. Steel Corporation is the largest shipper but does not hold the position of preponderance in Michigan as in the Lake Superior region in general, as shown in the table below.

PERCENTAGE OF TOTAL IRON ORE SHIPMENTS BY UNITED STATES STEEL CORPORATION FROM MICHIGAN AND THE LAKE SUPERIOR REGION.[4]

	Total.	U. S. Steel Corporation.	Independent companies.	Percentage U. S. Steel Corporation.
1909.				
Lake Superior Region	42,586,869	21,876,246	20,710,623	51.4
Michigan	11,979,229	2,894,516	9,084,713	24.08
1910.				
Lake Superior Region	43,442,397	22,185,972	21,256,425	51.00
Michigan	11,402,508	2,975,251	9,427,257	25.07

[4]Figures for Lake Superior Region taken from report of American Iron and Steel Association for 1910.

Of the total ore reserves as estimated by Finlay the independent companies control 142,047,548 tons or 72.3%, the U. S. Steel Corporation 54,307,335 tons or 27.7%.

MICHIGAN IRON ORE RESERVES BY RANGES, 1911.[5]

	Total reserves 1911.	Controlled by U. S. Steel Corporation.	Per cent.	Controlled by independent companies.	Per cent.
Gogebic	43,000,000	19,600,000	45.5	23,400,000	54.5
Iron River	42,122,000	1,400,000	3.3	40,722,000	96.7
Crystal Falls	8,054,000	625,000	7.7	7,429,000	92.3
Menominee, Metropolitan, Calumet	19,306,074	10,800,000	56	8,506,074	44.0
Marquette	77,126,651	21,616,335	28	55,510,316	72
Gwinn	6,746,158	266,000	3.9	6,480,158	96.1
	196,354,883	54,307,335	27.7	142,047,548	72.3

[5]Compiled from Appraisal of Michigan Mines, 1911, by J. R. Finlay.

Shipments by the Corporation and the Independent Companies seem to be about in proportion to reserves controlled.

PRICES OF MICHIGAN NATURAL IRON ORES AT LAKE ERIE PORTS FOR 1911 AND METHODS OF PRICE DETERMINATIONS.

In a subsequent table there is given the annual prices of Michigan iron ores at Lake Erie ports from 1855 to 1911. It must not be understood that the prices there given were actually paid per ton of ore handled. The desirability of an ore of a given class for furnace use varies with the iron, phosphorous, and moisture percentages, and for different physical characteristics, such as porosity, density, lumpiness, etc.

The figures given in the table are called *base prices*. The *base price* serves as a point of departure for determining the actual value of an ore, and is paid only for ores which exactly fill certain arbitrarily fixed percentages of iron, phosphorous, and moisture. The ores as mined and sold vary in both directions from these arbitrarily fixed standards.

Iron ores are sold by the gross or long ton of 2,240 pounds. The amount of metallic iron in a long ton of ore is the primary or chief (though not the only) measure of its value. The *unit of value* should therefore be based on a *unit* of metallic iron. The *iron unit* has, therefore, been established as 1% of a long ton. The number of *iron units* in a ton of *natural iron ore*, i. e., which has its natural percentage of moisture, is determined by subtracting from 100% the percentage of moisture in the natural iron ore and multiplying the remainder by the percentage of iron in the ore dried at 212° F.

The base value of a *unit* of *iron* in the standard grades is obtained by dividing the *Valley price* (which is the Lake Erie price, plus 60 cents) by the stipulated percentage of natural iron.

BASE PERCENTAGES, PRICES, AND IRON UNIT VALUES FOR LAKE SUPERIOR ORES, 1911.

Standard grade.	Natural iron per cent.	Phos. per cent.	Moist. per cent.	Iron dried per cent.	Lake Erie.	Valley.	Base unit value.
Old Range-Vermillion Bessemer	55.00	.045	10	61.12	$4.50	$5.10	$0.0927273
Mesabi Bessemer	55.00	.045	10	61.12	4.25	4.85	0.0881818
Old Range-Vermillion Non-Bessemer	51.50	....	12	58.52	3.70	4.30	0.0834951
Mesabi Non-Bessemer	51.50	....	12	58.52	3.50	4.10	0.0796116

The above table forms the basis for determining the prices of super standard and sub standard grades. The *iron unit value* in each grade fluctuates upward for each additional percent of natural iron and for Bessemer ores each decrease of .001% of phosphorous and downward for each decrease of 1% of natural iron and for Bessemer ores each increase of .001% of phosphorous.

The method for figuring premiums and penalties on Michigan ores, as illustrated in the Iron Trade Review[6] is as follows:

[6]Volume XLVIII, pp. 495-498. March 9, 1911.

BESSEMER ORES.

"To arrive at the value in figuring old range Bessemer ores varying from the base of 55 per cent iron natural to 50 per cent iron natural, there should be allowed from the base price for each unit under 55 per cent iron natural down to 50 per cent iron natural, the value of the base unit.

Mesabi Bessemer ores are figured in exactly the same way as old range Bessemer ores. In the case of both Mesabi and the old range Bessemeres, to better compensate the furnace-men on ores when running under 50 per cent iron natural, in addition to the value that would be arrived at on an ore running 50 per cent iron natural, there should be allowed for the unit of iron from 49 per cent to 50 per cent iron natural, the base unit value plus 50 per cent, and for the unit 48 per cent to 49 per cent, the allowance should be the base unit value of the ore plus 100 per cent.

The phosphorous adjustment should be made as per accompanying table. On Bessemer old range ores running above 55 per cent iron natural and up to 60 per cent iron natural, the value is arrived at as follows:

METHOD OF FIGURING PENALTIES AND PREMIUMS ON OLD RANGE BESSEMER ORES. VALUE OF UNIT OF IRON. (INCREASE OR DECREASE) BETWEEN POINTS SHOWN ONLY. BASE UNIT, $0.10182.

For penalty.	Value.
Per cent natural iron:	
48 to 49	$0.20364
49 to 50	0.15273
50 to 51	0.10182
51 to 52	0.10182
52 to 53	0.10182
53 to 54	0.10182
54 to 55	0.10182
For premium.	
55 to 56	0.11182
56 to 57	0.12182
57 to 58	0.13182
58 to 59	0.14182
59 to 60	0.15182
60 to 61	0.10182
For each succeeding unit beyond 60 per cent	0.10182

For the value of the unit:

Per cent.	Cents.
55 to 56—Add base unit value plus	1
56 to 57—Add base unit value plus	2.
57 to 58—Add base unit value plus	3.
58 to 59—Add base unit value plus	4.
59 to 60—Add base unit value plus	5.

Thus adding a premium of 15 cents per ton on ore running as high as 60 per cent and above in the iron natural condition. For each unit above 60 per cent iron natural, add simply the value of the base unit.

The method of figuring penalties and premiums may be illustrated in the following example on old range Bessemer ores running over and under the base ore of 55 per cent iron natural:

Value of base ore 55 per cent iron natural and 0.045 per cent phosphorous at 212 degrees Fahr.	$5.00
Descending scale—Ore guaranteed 48 per cent iron natural figured as follows:	
Per cent.	Cents.
55 to 50 equals five units at $0.10182	$0.5091
50 to 49 equals one unit at $0.10182 plus 50 per cent	0.15273
49 to 48 equals one unit at $0.10182 plus 100 per cent	0.20364
Deduct penalty	0.86547
Value of 48 per cent iron natural	$4.13
Value of base ore 55 per cent iron natural and 0.045 per cent phosphorous at 212 degrees Fahr.	$5.00
Ascending scale—Ore guaranteed at 61 per cent iron natural, figured as follows:	
Per cent. Cents.	
55 to 56 equals one unit at $0.10182 plus 1	$0.11182
56 to 57 equals one unit at 0.10182 plus 2	0.12182
57 to 58 equals one unit at 0.10182 plus 3	0.13182
58 to 59 equals one unit at 0.10182 plus 4	0.14182
59 to 60 equals one unit at 0.10182 plus 5	0.15182
60 to 61 equals one unit at 0.10182	0.10182
Add premium	0.76092
Value of 61 per cent iron natural	$5.76

Any variation in phosphorous from the base of 0.045 per cent, to increase or decrease the value of ores, is figured by the table of phosphorous values.

NON-BESSEMER ORES.

In figuring the value of non-Bessemer ores, both old range and Mesabi, running from 50 per cent iron natural to 53 per cent iron natural, adjustments are made by addition and subtraction from the base ore at the rate of the base unit for each unit.

METHOD OF FIGURING PENALTIES AND PREMIUMS ON OLD RANGE NON-BESSEMER ORES. VALUE OF UNIT OF IRON. (INCREASE OR DECREASE) BETWEEN POINTS SHOWN ONLY.

Base Unit, $0.0932.

For penalty.	Value.
Per cent natural iron:	
48.00 to 49.00	$0.1864
49.00 to 50.00	0.1398
50.00 to 51.00	0.0932
51.00 to 51.50	0.0466
For premium.	
51.50 to 52.00	0.0466
52.00 to 53.00	0.0932
53.00 to 54.00	0.1032
54.00 to 55.00	0.1132
55.00 to 56.00	0.1232
56.00 to 57.00	0.1332
57.00 to 58.00	0.1432
58.00 to 59.00	0.0932
For each succeeding unit beyond 58.00 per cent	0.0932

In figuring the value of an iron ore running below 50 per cent iron natural, the allowance for the unit between 50 and 49 per cent, should be the base unit plus 50 per cent, and for the unit between 49 and 48 per cent the allowance should be the base unit value of the ore plus 100 per cent.

On ores running over 53 per cent iron natural, there should be added to the base unit:

Iron ore, per cent.	Cents.
53 to 54—Base unit value plus	1.
54 to 55—Base unit value plus	2.
55 to 56—Base unit value plus	3.
56 to 57—Base unit value plus	4.
57 to 58—Base unit value plus	5.

In this way, adding a premium of 15 cents per ton to all ores running 58 per cent iron natural, or above, and for each unit above 58 per cent iron natural, add the value of the base unit. This method should be used on all ores in adjusting values and penalties down to 48 per cent iron natural condition.

The method of figuring penalties and premiums may be illustrated in the following example on old range non-Bessemer running over and under the base ore of 51.50 per cent iron natural:

Value of base ore 51.50 per cent iron natural	$4.20
Descending scale—Ore guaranteed 48 per cent iron natural.	
51.50 to 50.00 equals 1.50 units at $0.0932 plus 50 per cent	$0.1398
51.50 to 49.00 equals one unit at $0.0932 plus 50 per cent	0.1398
49.00 to 48.00 equals one unit at $0.0932 plus 100 per cent	0.1864
Penalty to deduct from base price	0.4660
	0.47
Value of old range Non-Bessemer ore at 48 per cent iron natural	$3.73
Value of base ore, 51.50 per cent iron natural	4.00
Ascending scale—Ore guaranteed 59 per cent iron natural:	
51.50 to 53.00 equals 1.50 units at $0.0932	$0.1398
53.00 to 54.00 equals one unit at $0.0932 plus 1 cent	0.1032
54.00 to 55.00 equals one unit at $0.0932 plus 2 cents	0.1132
55.00 to 56.00 equals one unit at $0.0932 plus 3 cents	0.1232
56.00 to 57.00 equals one unit at $0.0932 plus 4 cents	0.1332
57.00 to 58.00 equals one unit at $0.0932 plus 5 cents	0.1432
58.00 to 59.00 equals one unit at $0.0932	0.0932
Premium to add to base price	0.8490
	0.85
Value of old range Non-Bessemer ore at 59 per cent iron natural	$4.85

In using the accompanying phosphorous table in figuring Bessemer ores the per cent of phosphorous above or below 0.045, determines the value to be added to or subtracted from the value as determined from the iron content. If, for example, the ore has a phosphorous content of 0.046, 0.0080 is deducted from the value of the base unit. If the ore analyzes 0.044 per cent phosphorous, there must be added 0.0080, and so on, according to phosphorous content, the ore being more valuable for use in the Bessemer process as the phosphorous content decreases."

PHOSPHOROUS TABLE.

Percentage phosphorous.	Rate of progression.	Phosphorous values.	Percentage phosphorous.	Rate of progression.	Phosphorous values.
0.070	0.0200	0.3500	0.037	0.0115	0.0780
0.069	0.0195	0.3300	0.036	0.0120	0.0900
0.068	0.0190	0.3105	0.035	0.0125	0.1025
0.067	0.0185	0.2915	0.034	0.0130	0.1155
0.066	0.0180	0.2730	0.033	0.0135	0.1290
0.065	0.0175	0.2550	0.032	0.0140	0.1430
0.064	0.0170	0.2375	0.031	0.0145	0.1575
0.063	0.0165	0.2205	0.030	0.0150	0.1725
0.062	0.0160	0.2040	0.029	0.0155	0.1880
0.061	0.0155	0.1880	0.028	0.0160	0.2040
0.060	0.0150	0.1725	0.027	0.0165	0.2205
0.059	0.0145	0.1575	0.026	0.0170	0.2375
0.058	0.0140	0.1430	0.025	0.0175	0.2550
0.057	0.0135	0.1290	0.024	0.0180	0.2730
0.056	0.0130	0.1155	0.023	0.1085	0.2915
0.055	0.0125	0.1025	0.022	0.0190	0.3105
0.054	0.0120	0.0900	0.021	0.0195	0.3300
0.053	0.0115	0.0780	0.020	0.0200	0.3500
0.052	0.0110	0.0665	0.019	0.0205	0.3705
0.051	0.0105	0.0555	0.018	0.0210	0.3915
0.050	0.0100	0.0450	0.017	0.0215	0.4130
0.049	0.0095	0.0350	0.016	0.0220	0.4350
0.048	0.0090	0.0255	0.015	0.0225	0.4575
0.047	0.0085	0.0165	0.014	0.0230	0.4805
0.046	0.0080	0.0080	0.013	0.0235	0.5040
0.045	**0.0000**	**0.0000**	0.012	0.0240	0.5280
0.044	0.0080	0.0080	0.011	0.0245	0.5525
0.043	0.0085	0.0165	0.010	0.0250	0.5775
0.042	0.0090	0.0255	0.009	0.0255	0.6030
0.041	0.0095	0.0350	0.008	0.0260	0.6290
0.040	0.0100	0.0450	0.007	0.0265	0.6555
0.039	0.0105	0.0555	0.006	0.0270	0.6825
0.038	0.0110	0.0665	0.005	0.0275	0.7100

TRANSPORTATION.

Compared with other producing districts Michigan ore lies far from the main centers of smelting, manufacture and distribution. This disadvantage is more than offset by the richness of the ores. In the Lake Superior region Michigan enjoys over Minnesota the advantage of shorter rail and boat hauls and consequent lower freight rates.

The movement of ore to furnace is accomplished in three stages (1) mine to dock (2) lake haul (3) dock to furnace.

Mine to dock: At the mines the ore is loaded during the lake shipping season in part from pocket by gravity directly into hopper bottom or saddle back cars of 25 to 50 tons capacity and in part by steam shovel from stock pile. During the winter season the ore is stock-piled. The loading charge is borne by the mining companies. The ore carrying railroads, of the Lake Superior Region with, distances, rates, etc., appear in the following table.[7] The Michigan tonnage is carried by independent roads, with the exception of the Lake Superior and Ishpeming Railway which is controlled by the Cleveland Cliffs and Jones-Laughlin interests.

[7] Mon. 52, U. S. Geological Survey, p. 495.

ORE-CARRYING RAILROADS OF THE LAKE SUPERIOR REGION.

Railroads.	Ranges supplying traffic.	Principal range shipping points.	Lake termini at which ore docks are located.	Average haul, miles.	Approximate average cost per ton from mine to dock.
Duluth and Iron Range	Vermilion	Tower, Ely	Two Harbors, Minn	70–90	$0.90–$1.00
	Mesabi	Eveleth, Sparta, Biwabik		65	.80
Duluth, Mesabi and Northern	Mesabi	Virginia, Hibbing, Coleraine	Duluth, Minn	80	.60
Great Northern	Mesabi	Virginia, Hibbing, Nashwauk	Superior, Wis	120	.80
	Gogebic	Hurley, Ironwood, Bessemer, Wakefield	Ashland, Wis	40	
	Marquette	Michigamme, Negaunee		70	
	Swanzy	Princeton		45	
Chicago and Northwestern	Menominee	Iron Mountain, Norway	Escanaba, Mich	45	.40
	Crystal Falls	Crystal Falls, Amasa		80	
	Iron River	Iron River		83	
	Florence	Florence		63	
Duluth, Shore Shore and Atlantic	Marquette	Ishpeming, Negaunee, Michigamme	Marquette, Mich	12–15	.25
				35	
Lake Superior and Ishpeming	Marquette	Negaunee, Ishpeming	Marquette, Mich	12–15	.25
	Swanzy	Gwinn		36	
Wisconsin Central	Gogebic	Bessemer, Hurley, Ironwood	Ashland, Wis	50	.40
Chicago, Milwaukee and St. Paul	Menominee	Crystal Falls, Iron Mountain	Escanaba, Mich	40–60	.40

Ore Loading Docks: The loaded ore trains move out upon the ore docks where the ore is dropped directly into the dock pockets by opening the car bottoms. "There are many important considerations involved in the construction of the dock. The foundation is frequently 40 feet below water level and consists of a series of piling that cannot have much cross-bracing until the surface of the water is approximately reached. Above the water there is a height of from 60 to 70 feet and on top of this is the enormous moving loads of trains and locomotives, for an average of which 4,000,000 pounds is a low estimate. Air brakes on the trains stop them within a yard or two and consequently there is a pressure of about 2,500,000 foot-pounds to be taken up every time a train stops by the longitudinal bracing of the pier. Added to this is the fact that the center of permanent load may be 93 feet above foundation. The earlier docks were constructed of timber exclusively, but concrete and steel enter largely into the construction of the modern types. As the ships have grown larger and larger the docks have grown higher and higher in order to give the necessary slope to the chutes. Formerly the base of the pockets was only about 20 feet above water. In the more modern docks the hinge hold,

MICHIGAN

Railroad.	Location.	Dock No.	No. of pockets.	Storage capacity.
				Tons.
Chicago and Northwestern	Escanaba, Mich	1	184	21,143
Chicago and Northwestern	Escanaba, Mich	3	226	28,792
Chicago and Northwestern	Escanaba, Mich	4	250	34,925
Chicago and Northwestern	Escanaba, Mich	5	202	29,310
Chicago and Northwestern	Escanaba, Mich	6	320	69,760
Chicago and Northwestern	Ashland, Wisconsin	1	234	42,120
Chicago and Northwestern	Ashland, Wisconsin	2	234	42,120
			1,650	268,170
Duluth, South Shore and Atlantic	Marquette, Mich	4	200	28,000
Duluth, South Shore and Atlantic	Marquette, Mich	5	200	50,000
			400	78,000
Lake Superior and Ishpeming	Marquette, Mich	4	200	36,000
		2[2]	200	50,000
Chicago, Milwaukee and St. Paul	Escanaba, Mich	1	240	50,400
Chicago, Milwaukee and St. Paul	Escanaba, Mich	2	240	63,500
			480	113,900

[1]From outside to outside of semicircular bay.
[2]New dock will be in commission in 1912.

however, is 40 feet or more, above the water level."[8] The ore pockets of the loading docks are spaced 12 feet centers. This corresponds to the spacing of the hatches on some modern boats enabling a cargo to be taken by them without a shifting of position. Previous to 1902 the type ore freighter had hatches spaced at 24 feet centers.

The problem of unloading involves rapid manipulation of trains and shunting of cars to maintain definite fixed composition of the ore in individual pockets. The ore runs from the pockets of the dock directly into the hatches of the freighters. The cost of handling the ore from train to boat aggregates four cents per ton.[9] The boats are loaded with surprising rapidity. On Oct. 10th, 1909 at Two Harbors, Minnesota, the steamer William E. Corey loaded 10,111 gross tons of ore in 39 minutes.[10] The storage capacity of the docks is small compared to the tonnage which annually passes through them.

The location and capacities of the loading docks handling Michigan ore is given in table below.

[8]Ralph D. Williams in Iron Trade Review. April 27, 1911.
[9]Monograph 52 U. S. Geological Survey, p. 496.
[10]R. D. Williams in Iron Trade Review, April 27, 1911.

ORE DOCKS.[3]

Height from water to center hinge hole.	Height from water to deck of dock.	Width of dock from outside to outside of partition posts.	Length of spouts.	Length of dock.	Angle of pockets.	Capacity per pocket to bottom of stringers.
Ft. In.	Ft. In.	Ft. In.	Ft. In.	Feet.	Deg. Min.	Cubic Ft.
28 10	48 6	37	21	1,104	39 30	1,918
31 2	52 8	37	27	1,356	45	1,969
36 6	59 2	37	30	1,500	45	2,191
28 6	53 3	37	21 8	1,212	40	2,832
40	70	50 2	30	1,920	45	4,114
40	70	50 2	30	1,404	45	3,915
40	70	50 2	30	1,404	45	3,915
27 9	47 3	36 8	21 1	1,200	39 45	1,839
40	70 10	51	32 4	1,236	45	3,848
30 9	54	50	27 7	1,232	38 40	2,713
43	75	54[1]	35	1,200	45	4,546
40 2¾	66 6	52	120 27	1,500	45	2,900
40 11½	69 2	54	30 4½	1,500	45	3,150

[3]From Mon. 52, U. S. Geological Survey except data on Lake Superior and Ishpeming Ry., new dock No. 2 which was submitted by the owners.

The Lake Haul: From the loading docks the ore is carried in bulk freighters to lower lake ports. The first shipment was billed by the Hon. Peter White of Marquette in 1852 and comprised five barrels of ore. Since that time the size of cargo has increased by leaps and bounds with the deepening and widening of the Soo locks and growth of capacity of lake freighters. The largest cargo in 1856 was 400 tons; in 1866, 697 tons; in 1876, 1,360 tons, in 1886. 2,450 tons; in 1895, 3,843 tons, in 1900, 7,450 tons and in 1910, 13,410 tons.[11]

Unloading Docks: The cost of unloading at the lower lake ports is borne by the vessels out of freight earnings. The unloading charge in 1910, was 15 cents per ton. Williams states that the actual cost with clam shell buckets is less than 5 cents per ton.[12]

Dock to Furnace: From the unloading docks the ore is distributed by rail haul to the furnaces. The freight rates to principal smelting centers as compiled by the Pittsburgh Chamber of Commerce are given below.[13]

	Average distance.	Average rate per gross ton.	Average rate per ton per mile in mills.
Pittsburgh district	160	0.96	6.0
M. & S. valleys	81	0.56	7.1
Ashland, Ky	256	0.90	3.5
Bellaire, O	167	0.60	3.6
Columbus, O	124	0.50	4.0
Jackson, O	219	0.62½	2.9
Josephine, Pa	228	0.85	3.7
Max Meadow, Va	537	1.55	2.9
Midland, Pa	115	0.78	6.8
Punxsutawney, Pa	181	0.60	3.3
Roanoke, Va	550	1.55	2.8
So. Bethlehem, Pa	353	1.45	4.1
Wellston, O	208	0.62½	3.0
Wheeling, W. Va	164	0.60	3.7
Johnstown, Pa	224	1.16	5.2
Ironton, O	251	0.90	3.6
Zanesville, O	146	0.55	3.8
Philadelphia, Pa	422	1.45	3.4
Sparrows Point, Md	470	1.50	3.2
Wilmington, Del	471	1.45	3.1

TOTAL COST OF TRANSPORTATION.

The average rate per ton mile of moving iron ore on the Great Lakes is stated by Williams to have been .7 mill in 1909. For the same year the corresponding figure for freight transportation on

[11] Crowell & Murray. The Iron Ores of Lake Superior, 1910, p. 23.
[12] Ralph D. Williams in Iron Trade Review, April 27, 1911.
[13] Iron Trade Review, January 18, 1912.

the Lake Shore Ry. is 5.16 mills. In 1907 the average cost per ton of transporting Lake Superior ore to the furnaces was $2.14.[14] Annual Lake Erie prices and rail and boat freight rates from Michigan ranges from 1855 to 1911 are given in a subsequent table.

IRON ORE ANALYSES.

Iron ore is bought and sold mainly on the basis of chemical composition. Each cargo is sampled and analyzed at the mine and the mine analyses are checked by the furnacemen or buyers. In order to insure uniformity of results standard methods of sampling and analyses have been developed.

The ore is first dried at 100° C. (212° F.) to expel the uncombined moisture. This insures uniformity of physical and chemical composition at both ends of the haul. When the ore is charged into the furnace, however, it contains more or less uncombined moisture making necessary the calculation from the "dry" analysis the "natural" analysis for the use of the furnacemen. All ore analyses are carefully recorded and average cargo analyses by mines are annually published by the Lake Superior Iron Ore Association.

The accuracy of the sampling and analyses is illustrated by check figures on mine and furnace analyses on 21,030,909 tons of ore by the Oliver Mining Company in 1909.[15] The figures are given below.

	Iron.	Phos.	Silica.	Moisture.
Ave. Mine Analyses......	59.19	.068	6.38	12.22
Ave. Furnace Analyses...	59.04	.068	6.66	12.33

STANDARD CARGO SAMPLING METHOD.

The following is a description of the Sampling Method employed by the Independent Chemists of Cleveland.[16]

A continuous sample shall be taken from all cargoes, the weight of the sample varying with the size of the cargo.

This sample shall be taken with a galvanized iron scoop 3½" wide, 2¼" long and 1¼" deep, the handle 8" long; and with a hammer 12" long (the scoop holds approximately ½ pound).

It shall be the aim to take an equal bulk of ore from every point selected. When a lump is encountered a portion shall be broken off equal in bulk to a scoopful of soft ore. In sampling cargoes no sample shall be taken from the original outside surfaces on account of the presence of foreign matter and an undue proportion of fines.

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[14] Mon. 52, U. S. Geological Survey, p. 497.
[15] Mon. 52 U. S. Geological Survey, p. 498.
[16] Quoted from Crowell & Murray, The Iron Ores of the Lake Superior Region, 1910, p. 29-32.

SAMPLING OF SOFT ORE.

The sampler shall enter any hatch and begin sampling when the unloading machines have exposed five or six feet of the face.

In order to keep the size of samples within reasonable bounds and to gauge this size to the size of the boat, the sampler shall on cargoes up to 3,500 tons, begin sampling at a convenient point at the bottom of the face of the ore, and shall take one standard scoopful every two scoop lengths up the face of the ore to the top, and then shall move four scoop lengths to one side of the starting point before again sampling vertically. He shall continue in this manner keeping the above distances around the face of the ore to the place of beginning.

On cargoes from 3,500 to 6,000 tons, he shall use the two scoop lengths for vertical distances up the face of the ore, but move six scoop lengths horizontally.

On cargoes over 6,000 tons, he shall use the two scoop lengths for vertical distances up the face of the ore, but move eight scoop lengths horizontally.

The sampler shall then enter the next hatch working, and proceed to sample in the very same way, and so continue in every hatch.

The sampler shall then begin over again in the hatch in which he first started and continue the sampling in all the hatches provided there has been sufficient ore removed in the hatches since the faces were sampled to expose fresh ore.

The sampler shall continue this method of sampling in each hatch worked, until there is less than one-tenth of the ore left.

In sampling horizontal surfaces, as in boats where scrapers are used, the sampler shall sample every two scoop lengths lengthwise of the boat, the spaces between the lines of sampling to be 4-6-8 scoop lengths, according to the tonnage as described before.

SAMPLING OF HARD ORE.

In sampling hard lump ore the sampler shall begin sampling, and use the same spacing as defined for soft ore, using hammer lengths instead of scoop lengths. At each point sampled he shall take lump or fine ore equal to one cubic inch. In taking this cubic inch, the sampler shall take an average from the lump from which the cubic inch is broken.

MOISTURE SAMPLE.

The moisture sample shall be taken from the standard sample in the following manner:

When as many cans of ore have been filled as the stage of unloading will permit, the lump ore shall be broken up and the entire amount of ore so far taken shall be mixed and quartered twice, and from the last quarters to be rejected one scoopful for each can in the original sample shall be put into the moisture can, provided the total number of scoopfuls taken will produce a moisture sample weighing about 20 lbs. In case a moisture sample of such weight is not produced, the sampler shall take two or more scoopfuls per can from the rejected quarters, enough to produce about 20 lbs.

The moisture sample shall at once be placed in a standard moisture can with tightly fitted cover. This shall be accurately weighed, dried at 100° C. until the weight is constant. The loss in weight will represent the moisture in the cargo.

At certain unloading points, it is desired of the consignee of the ore, that the entire sample shall be dried and crushed before any quartering is done. At such unloading points the moisture sample shall be taken as follows:

The sample shall take one round from each hatch when it is one-half unloaded, three scoop lengths vertically and twelve scoop lengths horizontally, taking only ore from fresh surfaces which have not been exposed to sun or rain. It must be thoroughly mixed at once without breaking down, and 20 lbs. placed in a standard moisture can.

Whenever it is not practical to hold the entire sample until the close of the sampling, before mixing and quartering, it may be quartered at convenient stages of the sampling. This must be done each time exactly alike, by breaking down to one-half inch, mixing and quartering twice, thus preserving the proper proportion of the whole sample.

If in the final quartering the last two quarters exceed a can full, the ore shall be quartered again and one quarter rejected.

The sample may be quartered on the vessel, or may be taken to some other place suitable for that purpose. Samples must be shipped to the crushing plant in standard cans.

CAR SAMPLING.

Not less than ten equal sized samples are taken from each car. When cars are loaded with fine ore with piles in opposite ends, at least five samples are taken from each pile; the first one at the apex of the pile, and the other four at points symmetrically arranged around the sides of the pile, two-thirds of the distance from the apex to the base of the pile or sides of the car. With cars loaded in the center, the system is the same, except that the center of the side of the pile lengthwise of the car, is the first point and the other four being symmetrically arranged around this point.

When the ten points are located in a car, each of them is supposed to represent a definite area, equal to one-tenth of the ore surface of the car. If the car contains all fine ore, then ten equal sized samples are taken, one from each of the points. If the car contains a mixture of fine and lump ore, with varying amounts of each in the areas included in the different divisions, then each area is judged separately and stamped accordingly. The fine and lump ore are taken each in its proper proportions, the former with the scoop, the latter being chipped, or selected small pieces being taken, each about the size of the first joint of the thumb. The combined sample of fine, shipped and selected pieces from each area, equals the amount taken were it all fine ore. If the contents of the car were all lump ore, the proper sized pieces were chipped from four or five of the lumps in each of the ten areas, making forty or fifty pieces from each car, the total amount of the chipped pieces from each of the areas equalling the amount that would be taken were it all fine ore. All samples of fine ore are taken from well underneath the surface to obtain the ore in its natural state.

This method is based primarily on the assumption that a small representative portion of the ore taken from a large number of places in different parts of the cargo, will necessarily show the average composition of the cargo. Each year the Lake Superior ores are being more and more mixed, to establish certain grades. This mixture starts in the pockets of the loading docks, is continued as the various pockets are loaded in the boat, and further mixed as the ore is unloaded from the boat into cars or in stock pile, and again mixed as the ore is unloaded at its destination. It is in the case of the more or less mixed ores that the present standard method is particularly applicable. The Independent Chemists fully realize the importance of the sampling, and are ever ready to consider suggestions, whereby the present method may be improved.

CHAPTER III.

RECENT DEVELOPMENTS ON THE IRON RANGES.

With the exception of the Menominee, Calumet and Felch Mountain districts where exploration has been less active, recent development work on the Michigan iron ranges has in recent years added enormously to the available reserve iron ore tonnage. Some of the older mines have been rejuvenated by discovery of ore bodies at great depth and many new mines have been opened. Deep exploration, particularly in the Gogebic and Marquette districts has shown the existence of valuable large ore bodies and has removed the apprehension prevalent among many a few years ago regarding a possible general failure of the iron ore bodies to extend below moderate depths.

The Crystal Falls and Iron River districts, producers of non-Bessemer ore[1], have enjoyed several successive years of active exploration. The recent activity in these districts is due to the relative increase in consumption of non-Bessemer ore, to competition for reserves mainly among the independent producers of ore and iron products and to the existence in these districts of relatively large areas of unexplored ore-bearing formations under lands owned by a large number of small holders. The depression in the iron industry in 1911 had little effect on exploration in these districts.

In the following paragraphs there is briefly outlined recent progress in exploration and development on the different ranges.

MENOMINEE RANGE.

In common reference the Menominee Range includes the Menominee, Crystal Falls, Iron River, Calumet and Felch Mountain (Metropolitan) districts in Michigan and the Florence district of Wisconsin. The location of these districts and their relations are shown in Fig. 5.

MENOMINEE DISTRICT.

Opening of the District: "The opening of the Menominee range may be stated as being in 1870, when the first logs were cut, and

[1]The Mansfield Mine produces Bessemer ore.

floated down the Menominee river in 1871. Also in 1871, John L. Buel in company with John Armstrong made the first reported discovery of iron ore, and in 1872 the first exploring party entered this region under the guidance of Dr. N. P. Hulst, representing the Milwaukee Iron Co. In 1873 the discovery made by Buell and Armstrong was explored and developed. In 1874 fifty-five tons of this ore was hauled to Menominee and smelted, the results being most satisfactory and gratifying. The first mining of iron ore and its smelting was followed by numerous explorations and the rapid development of mines."[2] Shipments began in 1877 from the Breen and Vulcan mines over the Menominee River Railroad (Chicago and Northwestern Ry.) which reached the village of Quinnesec in this year and was extended to Iron Mountain in 1880. The district is served by the Chicago and Northwestern, the Chicago, Milwaukee and St. Paul and the Wisconsin and Michigan Railroads.

RECENT DEVELOPMENTS. WATER POWER, ETC.

The relation between the Hanbury slate and Quinnesec Schist: The true relations between the Quinnesec schist (effusive schistose greenstone) which occurs along the Menominee river and the Hanbury slates immediately adjacent to them on the north has long been a matter of doubt among geologists. W. S. Bayley concluded[3] that the Quinnesec schist is of Archean age and hence older and below the Hanbury slate. The contact between the two formations is not exposed in the Menominee district. If the Quinnesec schist is Archean, the occurrence of the Huronian formations along its northern edge is just short of a geological necessity, since under this view it is a legitimate inference that the schists are brought up on an anticlinal fold from the crest of which the Huronian series, which are developed in great thickness two to three miles north, have been eroded but should appear, in consequence of the structure, on the northern limb of the fold. The economic application of this theory consists in the possibility of the reappearance of the Vulcan iron-bearing member between the southern limits of the Hanbury slate and the Quinnesec schists.

Recent work, mainly by W. O. Hotchkiss,[4] in the Florence district of Wisconsin, has shown that the Quinnesec schists of that district, which are really continuous with the same formation of the southern part of the Menominee district, *overlie* the youngest

[2]Thomas Conlin and P. O'Brien. Lake Sup. Min. Inst. Vol. 16, p. 7, 1911. See also Proceedings of the Lake Sup. Inst. Min. Eng. for 1905.
[3]Monograph 46 U. S. Geological Survey.
[4]State Geologist of Wisconsin.

Huronian rocks, and are probably of late Upper Huronian age. The acceptance of this view clears up the question entirely and relieves us of the awkward necessity of explaining under the former theory why the Vulcan formation does not reappear, somewhere between the Hanbury slate and the Quinnesec schists. Exploration has not yet proved or disproved the absence of the Vulcan formation here, the reluctance of mining interests to undertake such exploration reflecting a disbelief in the probability of its occurrence. In the light of present information such disbelief is well founded.

Exploration in the Hanbury Slate. Some exploration has been done in the Hanbury slate none of which, however, has given encouragement for further work. Most of the formation is drift covered but enough is known to establish the fact that within it are beds of slaty siliceous iron carbonate and some ferruginous chert. The occurrence of ore bodies in the Hanbury formation is therefore a possibility, although not at present in the least degree an alluring one.

Water Power: The Menominee district possess an asset in the water powers of the Menominee river which bids fair to be in the future vigorously utilized. For many years a great compressor plant has been in operation at the Upper Quinnesec falls from which compressed air is conducted to the Chapin mine at Iron Mountain. The Sturgeon Falls is utilized by the Penn Iron Mining Co. in generating electric power which has displaced steam almost entirely for mine power.

The latest power project is that of the Peninsula Power Co., begun in 1911 at Twin Falls in Sec. 12, T. 40 N., R. 31 W. The dam is located at the lower fall and will develop a head of 42 feet, raising the water to a depth of 12½ feet over the rock sill of the upper fall. The plant is designed to generate 5,000 electrical H. P. which will be distributed over transmission lines to all of the mining districts in the Menominee ranges. The plant will be operated on the customs plan and the power sold to mines tributary to the various transmission lines.

ORE RESERVES.

The ore reserves of the Menominee district reported by Mr. J. R. Finlay to the Michigan State Tax Commission are given below.

ORE RESERVES. MENOMINEE DISTRICT. 1911.

Mine.	Reported in sight above bottom level.	Total tonnage expected by J. R. Finlay.
Cyclops, Norway, E. & W. Vulcan, Curry, Brier Hill	1,537,245	3,800,000
Pewabic	1,233,000	1,233,000
Loretto	1,107,424	2,000,000
Chapin	4,194,679	9,000,000
Aragon	1,085,000	1,800,000
Millie	20,000	400,000
Breen	....	....
Vivian	....	....
Quinnesec	....	....
Munro[5]	423,074	....
	9,600,422	18,233,000

[5]Ores are low grade. Not included in reserve tonnage estimate.

In contrast to the conditions in the Crystal Falls district and particularly the Iron River district the reserve tonnage is all in mines which have been producers for many years. The possibilities for opening new mines in the Menominee district are not, however, by any means exhausted.

CALUMET TROUGH.

Location and Extent: The Calumet trough is a synclinorium of Huronian sediments lying north of the Menominee district and trending in a general E-W direction through T. 41 N., Rs. 27, 28, 29 and 30 W. On the east the trough is lost beneath a covering of Paleozoic rocks and on the west it merges with the Menominee and Florence districts. (Fig. 5.)

The Iron (Vulcan) Formation. Distribution and Occurrences: The iron formation of the Calumet trough has been traced mainly by magnetic methods. (Fig. 6.) Natural exposures are rare. The formation has been opened at the old Hancock exploration in Sec. 30, T. 41 N., R. 27 W., at the Calumet Mine and vicinity in sections 8 and 9 and in pits and drill holes on Sections 16, 17 and 18, T. 41 N., R. 28 W. and farther east in an old shaft on the N. E. ¼ of the N. W. ¼ of Sec. 15, T. 41 N., R. 29 W. On the east end of the trough in township 40 and 41 N., Rs. 25, 26, and 27 W. are several small magnetic fields (Fig. 7) which indicates the presence of iron formation beneath the horizontal beds of sandstone and limestone which are here of considerable thickness. In the


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N. W. part of Section 3, T. 41 N., R. 37 W., a drill hole, put down several years ago, passed through 68 feet of limestone into steeply inclined gray quartzites and hard ferruginous slates, containing many streaks and then layers of red and gray hematite and magnetite. There is little in this hole to indicate that the formation would repay development.

Outside the Calumet mine, explorations in the Calumet trough have developed no iron formation of promising character.

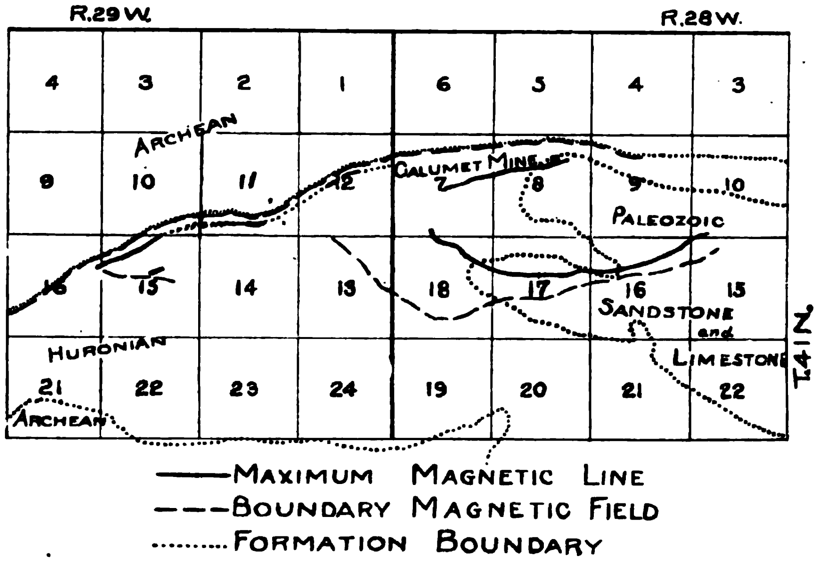

Fig. 6.—Magnetic lines indicating distribution of iron formation. From private surveys by R. C. Allen. Edw. Steidtman and others.

Calumet Mine: The strike of the iron formation at the Calumet mine is about N. 80° E, the dip varies from vertical to 80° south. There are three distinct iron bearing beds. The lens farthest north is about 60 feet thick, is overlain to the south by 35 feet of soft iron stained altered slate, 15 feet of iron formation, 15 feet of altered slate, 60 feet of iron formation. The upper iron bearing bed has a hanging wall of black slate. Beneath the iron bearing series lie in order the quartz schist, quartzite (combined thickness 250 feet) and dolomite of the Lower Huronian.

The iron formation consists of banded ferruginous chert and lean iron ore running between 40% and 50% iron. All of the ore in sight is low grade although some small high grade pockets have been mined. The Calumet mine has never been worked actively except at intermittent short periods. It was closed in May, 1910 and has on stock pile about 75,000 tons of 42% ore.

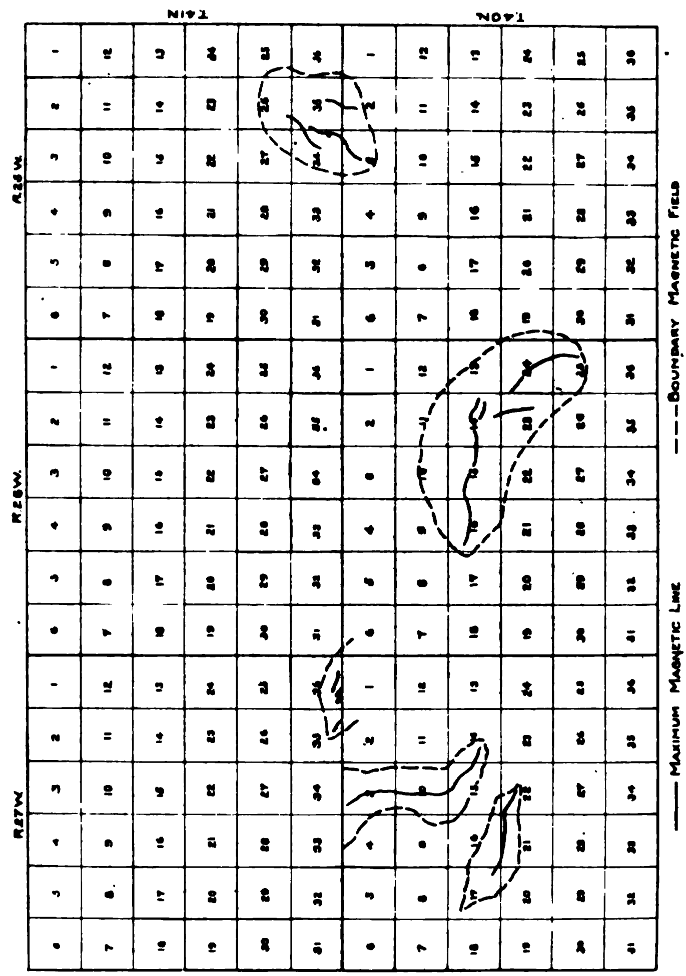

Fig. 7—Magnetic fields in southwest extension of Calumet trough. Compiled from private surveys.

THE METROPOLITAN TROUGH. (FELCH MOUNTAIN DISTRICT.)

The Metropolitan trough is a narrow complex synclinorium of Huronian rocks trending E.-W. through the southern portions of T. 42 N., Rs. 28, 29 and 30 west, thence across the northwest corner of T. 41 N., R. 30 W. into section 12, T. 41 N., R. 31 W. beyond which the structure is lost underneath glacial drift. The synclinorium is some eighteen miles long and varies from a half up to nearly two miles in width.

Distribution of the Iron (Vulcan) Formation. "In the Felch Mountain district the Vulcan formation is magnetic and has been traced by means of compass and dip needle. Excellent natural as well as numerous artificial exposures render the data concerning the distribution of the formation very satisfactory.

On the west the iron-bearing formation is exposed in ledges and test pits in sec. 5, T. 41 N., R. 30 W., from which a line of attraction extends southwestward through sec. 6 into sec. 12, T. 41 N., R. 31 W., where it is lost. The presence of the Vulcan formation through secs. 34, 35, and 36, T. 42 N., R. 30 W., is shown by one principal and other minor lines of attraction, as well as by test pits and outcrops. The principal line of attraction begins in sec. 34, near the southwest corner, and runs to the northeast, in conformity with the strike of the northern belt of dolomite, finally ending in the northeastern portion of sec. 36. This line of attraction is very vigorous and strongly marked. Two other lines, parallel with the principal line but more feeble and much shorter, cross the boundary between secs. 35 and 36. Another line, marking the west end of the Groveland syncline, begins near the center of sec. 36 and continues for 1½ miles eastward to the eastern portion of sec. 31, T. 42 N., R. 29 W. Along the western portion of this line are many test pits and in sec. 31 occur the fine exposures of the Groveland hill.

Another line of attraction begins 400 paces north of the center of sec. 32, T. 42 N., R. 29 W. which may be followed eastward without interruption nearly to the east line of sec. 33 of the same township. Along this line, which is comparatively feeble and crosses wet ground, there are but few test pits. In the eastern part of sec. 33, beyond the point at which the attraction ceases, many pits have been sunk to and into the Felch schist, which is there somewhat ferruginous. From this point eastward for 4 miles the Vulcan formation has not been recognized.

In the northern part of secs. 32 and 33, T. 42 N., R. 28 W., the ferruginous rocks are well exposed on Felch Mountain for nearly a mile along the strike, and may be identified for half a mile farther by the vigorous disturbances produced in the magnetic needles. In the S. E. ¼ sec. 33 the Vulcan formation is again encountered in a small and much disturbed area, in faulted contact with the Archean."[6]

Groveland Mine: The only active mine on the Metropolitan range is the Groveland in sec. 31, T. 42, R. 39, operated by the Groveland Mining Co. The mine is developed on three levels to a depth of 275 feet. The ore is hard blue hematite and specular

[6]Monograph 52, U. S. Geological Survey.

hematite of low grade. A forty acre tract adjacent to the Groveland on the east was recently drilled by the Breitung interests. The formation here is of the character shown in the Groveland workings.

CRYSTAL FALLS DISTRICT.

The opening of the Crystal Falls district dates from the spring of 1882 when shipments began over the Chicago and Northwestern Ry., which was completed from Stager in April of that year. In 1888 a branch was built to Amasa thus affording an outlet for the ore of that vicinity. The Chicago, Milwaukee and St. Paul Ry. was built from Channing to Amasa in 1893, the vicinity of Crystal Falls being served by a spur from Kelso.

As in the Iron River district, ore had been discovered and considerable development work accomplished before the building of the railroad, which came after the prospectors had demonstrated the ore bearing possibilities of the district. The earliest of these prospectors was Mr. "Jack" Armstrong who is credited with the first discovery of ore, the sight being on Lot 3, sec. 20, 43-32.

The production of the district rose steadily to 1892 when 603,048 tons were shipped. This figure was not reattained until 1898 due to slump following the panic of 1893. Since 1898 the production has fluctuated between 1,631,484 tons in 1907 and 629,602 tons the following year.

THE IRON FORMATION AND ITS OCCURRENCES. RECENT DEVELOPMENTS.

The distribution of the iron (Vulcan) formation is indicated in Fig. 5. The thickness of the formation is not above 300 to 400 feet. As in the Iron River district the iron formation occurs in lenses in the Michigamme slate and at different horizons in the slate and presents therefore precisely similar (but not so great) difficulties to successful structural interpretation. At Amasa and in the vicinity of Crystal Falls, the iron formation is separated from the Hemlock greenstone by small but variable thicknesses of slate and is therefore near the base of the Upper Huronian series.

In the northeastern part of the district a great oval area of Archean and Lower Huronian rocks is almost surrounded by a belt of iron formation. That on the east side of the oval is believed to be of Negaunee age but that on the west is Upper Huronian. Little is known of the character of the Negaunee formation over the greater part of the belt on the west. It was mapped mainly on the basis of a magnetic line but is partially opened in the Sholdice exploration in the S. E. 1/4 of the N. E. 1/4 of Section 21, T. 45 N., R. 31 W. On the Sholdice exploration the formation is fine grained, dense banded, hematite and reddish quartz or chert. The hematite bands vary from less than an inch to a few feet in width. The ore thus far shown is too lean for present use.

On the west side of this oval, going southward, the first important exploration is the Red Rock (Channing) on the N. E. 1/4 of the S. E. 1/4 of Sec. 20, T. 45 N., R. 33 W. The exploration was temporarily abandoned in 1911 by the Verona Mining Co. A shaft, located 180′ east and 125′ north of the center of the S. E. 1/4 of the section was sunk 327′. Considerable lean ore was encountered on the first level and on the second level west of the shaft at 228′ from the surface ore was found which, however, did not extend downward to the third level. The strike of the formation is N. E.-S. W.

From the Red Rock the iron formation probably extends at least as far north as the middle of section 16, T. 45, R. 33, from which point south through the Red Rock property and thence into the iron formation at Amasa is a practically continuous magnetic belt.

At Amasa are the Hemlock and Michigan mines. The Hemlock is developed to the fourteenth level at a vertical depth of 1,020 feet. The shaft is in greenstone and is inclined at about 60°. The ore is separated from the greenstone by a slight thickness of slate but at least in one place the iron formation lies directly on the greenstone. The ore in this mine from the 12th level to the surface averaged 15′ to 20′ thick and formed a tabular body striking N. W.-S. E. and dipping S. W. at about 70° with a minor fold on the 6th level throwing the ore about 20′ further west on lower levels. At the 12th level the dip flattened out, the ore maintaining a thickness of about 20′ and pitching at an angle of about 20° northwest through the 13th level down to about the 14th level where it apparently disappears. On the failure or success of efforts to locate a possible extension of the ore body depends the life of the Hemlock mine. The outlook is not at present very encouraging.

The Hemlock ore body has on most levels extended southeast into the Michigan mine of the Oliver Mining Co. The Michigan has been closed for much of the time in recent years and is not being actively worked. About two miles southeast of the Michigan mine is the Gibson Exploration where work has been under way for a number of years by the Rogers-Brown Ore Co. The Gibson is presumably on the same iron bearing horizon as the Hemlock and

Michigan mines but has not developed any considerable tonnage of marketable ore. The pumps were pulled and the mine closed in July, 1911. A considerable tonnage which had accumulated in stock pile was shipped.

Between the Michigan and the Gibson, the iron formation is being explored by the Pickands-Mather interests on Sec. 9, T. 44 N., R. 33 W. The exploration is known as the Warner-Corry. The results of the work here thus far show a formation of promising character.

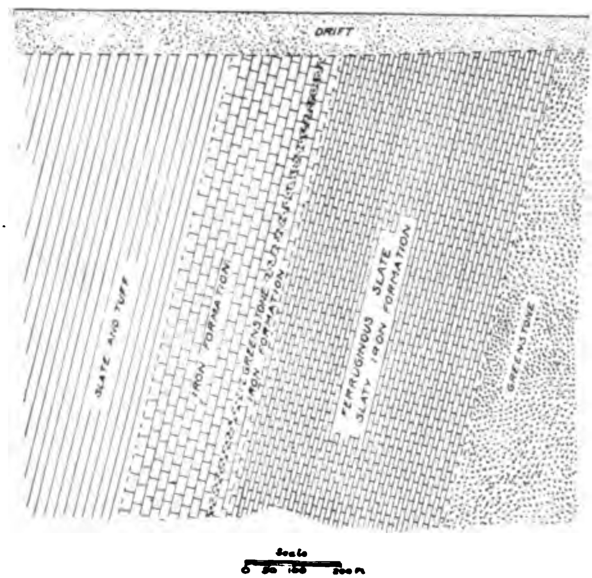

Fig. 8.—Generalized section showing thickness and relations of the iron formation on the Porter-Amasa property. Compiled from plats furnished by the E. J. Longyear Co.

Southeast of the Gibson on the N. E. ¼ of Section 22, T. 44 N., R. 33 W. is the Porter-Amasa exploration owned by the Nevada Land Co. Drilling by the Shenango Furnace Co. demonstrated the presence of iron formation here some years ago. Recent exploration by the E. J. Longyear Co. has revealed an ore body of considerable dimensions, part of it of Bessemer grade. The ore body so far as known from drill records is of tabular shape and steeply inclined to the southwest similar to other deposits on this belt. Steps have not yet been taken to open a mine but it is probable that an ore body of this desirable quality will not long remain unopened.

Southeast of the Porter-Amasa exploration work, has been in progress by the Rogers-Brown Ore Co. and the St. Clair interests on Sec. 23 and by the Florence Iron Co. on Sec. 36, T. 44 N., R. 33 W. These properties are said to be crossed by a magnetic line and it is thought that the iron bearing horizon of the Hemlock, Michigan, Gibson and Porter properties passes through the section. (Fig. 5) Ore is reported to have been cut on Sec. 26 to the N. W. and also on Sec. 6, T. 43, R. 32, adjacent on the S. E.

Still farther southeast in the northern part of Sec. 14, T. 43 N. R. 32 W. the iron bearing horizon was penetrated in drill holes several years ago. The records of some of these holes are of encouraging character and unite to further exploration.

From Section 14, the iron bearing horizon turns south and passes through the Hollister, McDonald and Armenia mines. The Hollister mine has been developed on mine levels to a depth of 750 feet. The strike of the formations here is 10° E. of south. The workings are all west of the shaft in a steeply westward dipping series of slate and iron formation. East of the shaft about 1,500′ are greenstone outcrops. The Hollister ore runs so high in moisture that experiments have been conducted on drying before shipment. A plant was installed by G. C. Olmstead in the summer of 1911 with capacity of 300 tons per 24 hours. Ore is taken from the skips and, broken through a grizzly, from which it is caught on a Robbins belt conveyor and carried into a hopper feed discharging into an inclined revolving drum heated by stokers. Hot gases are carried through the drum over the ore and out the stack. The ore is received at the low end of the revolving drum by a bucket elevator and delivered to tram cars operated on trestle above stock pile. The Hollister experiments if thoroughly carried out will determine the commercial feasibility of ore drying at the mine. If the saving on freight and ultimately fuel in smelting is greater than the cost of drying the process will be profitable.

South of the Hollister about ¾ mile on the S. E. ¼ of the N. E. ¼ of T. 43 N., R. 32 W. is the McDonald, a new property which has been in course of development by the McDonald Mining Co. for the past four years. The shaft is now 300′ deep and the property is partly developed on three levels. The iron formation is said by Capt. A. E. Drake in charge to measure about 500′ wide, is highly folded and brecciated and lies on a slate foot wall dipping steeply east. The workings lie west of the shaft which is in slate. Some ore is showing on three levels. The bodies thus far opened are irregular small concentrations but the property is only partially explored and its possibilities are not yet tested.

East of the Hollister and McDonald mines, the slate-iron formation series is caught in a deep southward projecting embayment in the Hemlock greenstone. In this embayment is the site of the old Bird exploration. The shaft, 80′ to 100′ deep, is on the S. E. ¼ of the S. E. ¼ of Sec. 13, T. 43 N., R. 32 W. The Bird section is interesting in that it displays on exposure and in an E.-W. trench a short distance north of the shaft the relations between the greenstone and the slate-iron formation series. Beginning on the top of the greenstone belt west of the shaft and proceeding eastward there is exposed in a steeply eastward dipping series:

0-15	paces.	Six flows of green stone, the top and bottom of each flow showing well develowed amygdaloidal textures.
20-26	"	Greenstone flow.
26-29	"	Greenstone flow.
29-34	"	Greenstone flow.
34-48	"	Covered.
45-53	"	Greenstone flow.
53-91	"	Greenstone flow.
91-106	"	Lean ferruginous slate.
106-118	"	Greenstone-jasper conglomerate.
118-135	"	Iron formation.
135-158	"	Ferruginous slate.
158-		Beyond 158 paces a trench continues into a swamp but no rock is showing in the bottom. Across the swamp to the east are greenstone outcrops.

This succession indicates the conformable relations and interbedding of the greenstone flows and iron formation slate rocks. In some flows there are banded siliceous jaspery stringers following around between the ellipsoids, simulating flow structure. In one instance a stringer of this material is 8 inches wide and 8 feet long passing off the outcrop beneath the drift covering. Some of the jasper bands plainly follow flow lines in the greenstone and are plainly contemporaneous and genetically related in origin to the greenstone. (Compare Porter-Amasa Section, Fig. 8.)

East of the Bird location in the N. W. ¼ of Section 20, T. 43 N., R. 31 W. is the Mansfield mine which has the distinction of being the only producer of Bessemer ore in the Crystal Falls district. The mine is located in a narrow tongue of slate, averaging about a quarter of a mile wide, extending northward 3 miles into the greenstone from sections 31 and 32 into the south edge of sections 7 and 8. The Mansfield ore bearing horizon is from 8 to 15 feet thick dipping steeply westward between slate walls. The mine is developed to a depth of 1,390 feet.

About 1/4 mile south of the McDonald is the Armenia mine on the N. E. 1/4 of the S. E. 1/4 of Section 23, T. 42 N., R. 32 W., operated by Corrigan-McKinney Co. The mine is developed to the seventh level at a depth of 690 feet. From the Armenia it is about 3/4 mile slightly east of south to the old Lee Peck exploration. From the vicinity of the Lee Peck the iron bearing horizon probably extends a little south of east through the old Hope exploration, which is in promising looking iron formation, and thence on about the same course through the old May exploration in the S. E. 1/4 of the S. E. 1/4 of Section 28, and thence east through the Kimball mine on the S. E. 1/4 of the S. E. 1/4 of Sec. 29, a low grade property controlled by Corrigan, McKinney Co. which has been idle for a number of years.

From the Kimball it is about 2 miles slightly south of east through the old Shaefer mine to the Tobin mine and the iron formation, from all available structural data, if continuous, should cross the intervening area. The Tobin is developed to the eleventh level at 1,100 feet depth. Development is in progress on the twelfth level 125 feet lower.

One of the most important explorations of the year 1911 is that in progress by the M. A. Hanna Co. just south of the Tobin on Sec. 31, T. 43 N., R. 32 W., lying between the Tobin mine on the north and the Dunn on the south. The property is known as the Monongahela-Carpenter. The results of over a year's drilling has shown up a considerable tonnage of ore of good grade and the Monongahela-Carpenter bids fair to become one of the large mines of the district.

South of the Monongahela in the N. E. 1/4 of Sec. 1, T. 42 N., R. 33 W., is the Dunn mine the deepest and one of the oldest mines in the district. It is opened to the 11th level at a depth of 1,420 feet. The reserves in the mine are approaching exhaustion and its continued operation will depend on opening new tonnage which is considered by the management not likely to occur.

From the Dunn the trend of the iron formation continues southward through the South Dunn exploration on the N. E. 1/4 of the S. E. 1/4 of Section 1, T. 42 N., R. 33 W. Exploration was conducted here in 1908 by the Munroe Iron Mining Co. A shaft was sunk and considerable underground work was done which on the whole seemed not to yield satisfactory results and the exploration was abandoned. The best ore was encountered south of the shaft in a drift from the 175 foot level which passed through forty feet averaging about 60% in iron, non-Bessemer. Although the formation is twisted and contorted, the general strike is probably about south. In this general direction a local magnetic field occurs on the N.-S. quarter line of the section about ¾ mile from the south Dunn shaft.

Still farther south in sections 12, 13 and 14 is the Alpha-Mastodon-Delphic area. This area which has not produced for many years has been rejuvenated by recent exploratory work of the Nevada Land Co. Drilling was conducted for over two years on the old Alpha location (S. W. ¼ of S. W. ¼ of Sec. 12, T. 42 N., R. 33 W.) and the vicinity of the workings thoroughly explored without encouraging result. Proceeding southeastward on the strike of the iron formation with closely spaced drill holes ore was finally located near the south line of the section in a swamp along Mastodon Creek. The ore lies on a gray slate foot wall dipping about 35° S. E., is of high grade non-Bessemer quality and the deposit has already assumed very considerable dimensions. Drilling is still in progress.

Considerable drilling has also been done by the Nevada Land Co. on the old Delphic location (N. W. ¼ of S. E. ¼ of Sec. 24, T. 42 N., R. 33 W.) and is still in progress. The iron formation strikes northeast from the old Delphic pit and has been followed by drilling into the swamp in the northern part of the section. From the Delphic location the general trend of the slate iron formation series continues apparently slightly south of east into Wisconsin.

We have now traced for upwards of 30 miles a practically continuous iron bearing horizon. Along this belt there doubtless remains to be discovered many ore deposits in addition to these now known. Considering the amount of explorable ground on this belt with the character and number of deposits already known it is probably true that its reserves are hardly more than beginning to be known.

North of Crystal Falls is a second productive belt trending from the Ravenna exploration in Sec. 19, T. 43 N., R. 32 W., east through the Bristol and Great Western mines and thence apparently northeast through the Crystal Falls and Hill Top properties into the Victoria exploration in the N. W. ¼ of the N. W. ¼ of Sec. 22. The active mines on this belt are the Bristol and Great Western but the Great Western was practically idle during 1911. This belt is paralled on the north by greenstone to which it bears about the same stratigraphic relation that is exhibited by the Amasa belt discussed above. It is, however, apparently considerably higher up in the slate series.

The Ravenna is a recent exploration of M. A. Hanna & Co. It adjoins the Bristol on the west. Considerable drilling has been done and a shaft put down from which drifting is being done on the first level proving the continuation of the iron formation from the Bristol property. Some ore has been encountered but as yet not in any considerable quantity.

The Bristol Mine (N. E. 1/4 of S. E. 1/4 of Sec. 19, T. 43 N., R. 32 W.) is developed to a depth of 960 feet. The iron formation strikes E.-W., dips vertical or steeply southward and is about 350′ thick enclosed in black slate walls. In the west end of the mine a black slate wedge appears in the middle of the formation. It is 50′ thick at the hoisting shaft and widens westward. Its thickness is included in that of the iron formation. The ore is now being drawn from a low grade body running 49 to 55% iron and 3% manganese. It lies just south of the open pit and extends downward to the 8th level and below dipping south at a high angle and pitching slightly west. The workings extend to the east line of the property but in this vicinity the ore runs only about 45% iron. The ore in the Bristol mine is apparently not related to slate walls or slate troughs but is simply enriched layers in the iron formation which may occur anywhere in the mine. The phosphorous content of the ore has been about the same throughout the mine but the sulphur content according to Capt. Bjork rises with depth. A new shaft is being sunk in black slate about 360′ N. W. of the hoisting shaft now in use.

Geological conditions very similar to those of the Bristol mine are met with in other properties on this belt including the Great Western.

An important recent development on this belt is that made by Mr. B. F. Neely east of the Great Western mine on the N. E. 1/4 of the S. E. 1/4 of Section 21, 43 N., 32 W. A large tonnage of ore has been located by drilling on this description but as yet no steps have been taken to mine it. This deposit is considered practically an extension of the Great Western ore body.

From the above location the iron formation extends northward through the Crystal Falls and Hilltop mines which have long been idle into the Victoria exploration (N. W. 1/4 of N. W. 1/4 of Sec. 22) where it is reported that development work will be resumed in the near future.

ORE RESERVES.

The following is the estimated ore reserves of the district reported by J. R. Finlay to the Michigan State Tax Commission in 1911.

ORE RESERVES, CRYSTAL FALLS DISTRICT, 1911.

Mine.	Reported in sight above bottom level.	Total tonnage expected by J. R. Finlay.
Hollister	....	....
Crystal Falls	42,000	500,000
McDonald	10,000	....
Mansfield	32,000	525,000
Fairbanks	....	....
Bristol	522,000	1,500,000
Armenia	50,300	550,000
Great Western	97,300	800,000
Tobin	135,300	1,800,000
Kimball	....	....
Dunn	67,000	117,000
Michigan	78,000	100,000
Hemlock	125,000	180,000
Channing	75,000	75,000
Youngstown	....	40,000
Amasa-Porter	....	330,000
Alpha	....	60,000
Neely	....	587,000
Hill Top	....	10,000
Monongahela-Carpenter	....	320,000
Extension Great Western	....	200,000
	1,233,900	8,054,000

From the above estimates it appears that the reserves are equal to about half of the total shipments and that 21 per cent of the reserves are in properties which have not reached the producing stage.

IRON RIVER DISTRICT.

The Iron River district lies north, east, south and west of Iron River the center of industry. The district has no natural well defined geological boundaries, except on the south. The area of mining operations is being constantly extended.

Ore was discovered by Mr. Harvey Mellen, a United States land surveyor on Aug. 8th, 1851, on the west face of Stambaugh hill in Sec. 36, T. 43 N., R. 35 W. The opening of the district dates from the fall of 1882 when the Chicago and Northwestern Ry. reached the district with a spur from Iron River Junction, now Stager. In 1887 this line was completed to Ironwood.

From 1882 to 1893 the only important shippers were the Iron River and Beta mines, the former being on the site of Mr. Mellen's discovery of 1851. The shipments to 1893 totaled 1,130,444 tons. From 1893 to 1899 practically no mining was done but since the latter date development has gone steadily and in recent years rapidly forward.

Regarding the distribution of the iron formation much is yet to be known because of the general absence of exposures and the necessity of reliance on information furnished by underground exploration. Rapid as has been the exploration of this district in recent years the results are still far from adequate for purposes of general mapping. The areas of known iron formation were mapped by the Michigan Geological Survey in 1909.[7] These areas have been considerably extended by recent work.

DISTRIBUTION OF THE IRON FORMATION.

The known main occurrences of the Vulcan formation may be referred to three different areas, viz., (1) the Jumbo belt just south of Brule river in Florence county, Wisconsin, about 1½ mile east of Saunders; (2) the central producing area of unestablished boundaries; (3) the Morrison Creek belt in Sec. 24, T. 44 N., R. 35 W. and (4) the Atkinson belt, southwest of Atkinson. Exploration has not demonstrated that the Jumbo, Morrison Creek, and Atkinson belts carry important ore bodies. Such exploration as they have received has not been encouraging.

The Vulcan formation of the producing area has a thickness at maximum of 300 to 400 feet. It is nearly everywhere steeply inclined and in consequence its exposures are generally narrow and not greatly in excess of its thickness. From the studies which have been made in this district, I am convinced that the Vulcan formation occurs here in more or less discontinuous lenses in the Michigamme slate. A given horizon which carries in one place slate may in another not far distant carry iron formation and vice versa. This concept has a direct bearing on exploration. In one sense it simplifies the structural problems, which will in time be solved as new data is obtained, and in another sense it complicates the problems. If true, it limits the value of the iron formation as a horizon marker over any but local areas but on the other hand obviates the necessity of introducing great faulting and improbable structures to account for the facts of distribution. These considerations do not, however, complicate the problem of the general structure of the district of which much is known.

[7] Publication 3. Geological Series 2, Mich. Geol. Sur. 1910. Monograph 52. U. S. Geological Survey, 1911.

WESTWARD EXTENSION OF THE IRON RIVER IRON-BEARING SERIES.

In 1910 I called attention[8] to features of general structure which seemed to indicate a westward extension of the iron bearing series of the Iron River district. Mining men have had in mind for some years a possible connection between the Gogebic and Iron River districts. On early general geological maps the supposed Archean boundary to the south of the Menominee ranges was brought in from Wisconsin in the vicinity of Lac Vieux Desert and extended thence, in general, northwesterly to connect with the north boundary of the Archean mass which lies immediately south of the Gogebic district.

The work of 1909 in the Iron River district encouraged us to push on westward in quest mainly of information bearing on the problem of a possible westward extension of the iron-bearing series of the Iron River district. The results thus far have not been altogether discouraging and I shall outline below the aspects of the problem as they appear.

Referring now to Fig. 5, it will be seen that the producing area of the Iron River district is cut off on the south by the Lower Huronian series striking west into the south part of T. 42 N., R. 36 W. On the north it is limited by a great series of presumably but not certainly younger metamorphosed graywackes, slates and volcanic greenstones trending on the average a little south of west. Between the Lower Huronian on the south, and its projected westward extension, and the graywacke-slate-greenstone mass on the north lie the drift covered townships 42 N., Rs. 36, 37 and 38 W., west of Iron River. Here, if anywhere, lies the westward extension of the Iron River series. In this area there are no exposures. Dip needle readings taken on N.-S. lines run at ¼ and ½ mile intervals show no appreciable variations up to the middle of T. 43 N., R. 37 W. Beginning in Section 16 of this township a magnetic belt extends through sections 17 and 18 into Section 13, T. 43 N., R. 38 W. where it dies out reappearing, however, in section 15 extending thence westerly across the state boundary into Wisconsin. (Fig. 9.)

This magnetic belt is probably caused by an iron formation. It indicates the strike or trend of the formations in this area which is in line with the supposed strike determined as above by study of the structure of the rocks lying north and south of the Iron River iron bearing series and their westward extension. Presumably,

[8] Publication 3, Michigan Geological Survey.

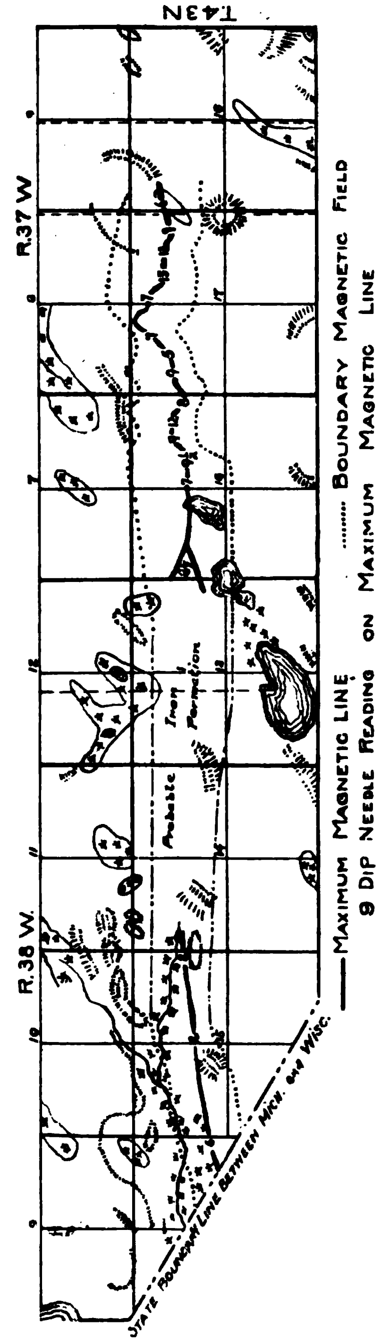

Fig. 9.—Magnetic belt in T. 43 N., R. 37 W., and T. 43 N., R. 38 W.

the probable iron formation underlying this magnetic belt, and probably extending eastward where no magnetic variations occur, is of Upper Huronian age and is decidedly worth exploring.

In township 45 N., R. 39 W., extending in an E.-W. direction just south of Watersmeet is another magnetic belt. In the north part of this township are outcrops of acid gneisses which are probably Archean. It is not known how far south in this township these rocks extend owing to lack of exposures but the south edge is undoubtedly north of the Watersmeet magnetic belt. This belt is in all probability underlain by iron formation, whether of Archean or later age is not known. It extends westward beyond the point shown on the plat where it was dropped at the close of the 1911 field season.

Further work planned for the season of 1912 will throw more light on the structural conditions here discussed but enough is already known to demonstrate that there is no direct connection between the Gogebic and the Iron River districts. The iron bearing series of the latter if continuous westward, which is a probability, passes south of the Archean mass which limits the Gogebic district on the south. Further work west of Watersmeet and southward to the state line is expected to reveal magnetic lines indicating the probable presence of iron formation and a continuance of the westward trend of the structures discussed above.

ORE RESERVES.

The development work of the last few years has shown two important and striking facts bearing on the future of this district, viz., (1) the ore bearing formation is exceedingly rich, i. e., the ratio of the volume of known ore to known iron formation is relatively high and (2) ore reserves have already mounted to a high figure. The Iron River district has one of the great ore reserves of the state if not actually the largest. The following table is taken from the report of J. R. Finlay to the State Tax Commission, 1911.

ORE RESERVES, IRON RIVER DISTRICT, 1911.

	Reported in sight above bottom level.	Total tonnage expected by J. R. Finlay.
Osana (James)	520,000	2,000,000
Chatham	43,000	100,000
Hiawatha	254,993	1,000,000
Baker & Tully	3,500,000	3,500,000
Dober (Riverton)	713,000	1,700,000
Baltic Fogarty	460,000	3,000,000
Caspian	3,505,500	10,000,000
Youngs	250,000	1,000,000
Zimmerman	1,000,000	1,000,000.
Berkshire	563,000	1,000,000
Davidson	2,000,000	2,000,000
Wauseca	40,000	1,000,000
Chicagon	390,305	600,000
Michael Expl	1,000,000	1,000,000
Blair Expl	372,259	1,400,000
Houlihan	578,000	5,000,000
Rogers	349,306	2,500,000
Donahue	371,437	800,000
McGovern	258,413	350,000
Bates	....	400,000
Wickwire	....	40,000
Erickson	....	732,000
N. Y. State Steel	....	2,000,000
	10,169,213	42,122,000

The above estimates bring out the striking fact that this district has an expected tonnage in mines and explorations of 7 times the total shipments and furthermore that 15,822,000 tons or over 37% of the reserves is in properties which have not reached the producing stage.[9]

RECENT DEVELOPMENTS.

In 1910 attention was called to a possible southwestward extension of the iron formation through sections 15, 16 and 17, T. 42 N., R. 34 W. Since that date exploration has not been active on this indicated extension.

Proceeding northwestward important developments have been made at the Zimmerman Mine. The management here who formerly were dependent for the small output of the mine on small irregular ore bodies has succeeded in locating on the 4th level what bids fair to be a body of considerable proportions. The ore lies in a syncline of the drag fold type pitching northeast and slightly overturned toward the southwest. The ore extends upward from the 4th level to the surface. Its downward extension has not been

[9]The Chicagon shipped in 1911.

determined, but ore is known at 600 feet in depth. In its present state of development this body is estimated to contain not less than 1,000,000 tons.

At the Baltic, Youngs and the Fogarty properties, we have to record no important recent development. The Baltic is developed to the seventh level 553′ below collar of No. 2 shaft. The reserves above this level are still nearly half the total shipments from the mine with promise of substantial tonnage below this level. The Fogarty is developed to the third level at a depth of 260′. The mine was closed for over a year prior to May 15, 1911. The mine can produce steadily a moderate tonnage, which is also true of the Youngs mine adjacent to it on the south.

The Berkshire Mine has developed levels at 165, 265 and 365 feet. The strike of the ore body is eastward with the iron formation. The pitch is apparently also eastward, particularly in the west end of the mine where the ore is thrown eastward 160 feet in a vertical distance of 100 feet. The ore lies on a black slate wall dipping south at a high angle to the second level and thence downward vertical. The formation in the east end of the mine is swinging northward. The mine is young and the reserves already known are hardly more than opened up.

Adjacent to the Berkshire on the east is the Corry exploration which was drilled with encouraging results by the Verona Mining Co. It has been taken over by the Michigan Mining Co.,[10] who are conducting development work through a vertical shaft near the east central side of the property.

At the Caspian Mine, developments have not proceeded beyond the 3rd level 292 feet below surface. The area of developed ore on this level is 377,000 sq. feet. The ore body is by far the largest in the district and bids fair to development into one of the great deposits of the Lake Superior region.

North of the Caspian is the Tully property, which has now reached a producing stage. Drilling on the Tully has shown a large tonnage of ore. The ore from the Baker, adjacent to the Tully on the east, will be hoisted through the Tully shaft. The Baker was closed in June of 1911, owing to a refusal of the fee owners to allow operators to hoist Tully ore through the Baker shaft.

The Verona Mining Co. after several years of exploration has developed a very promising ore body on the Barrass-Houlihan property. The ore body lies in the middle east side of the N. W. ¼ of the S. E. ¼ of Sec. 36, 43 N., 35 W. It is partially developed on

[10]The Michigan Mining Co. was recently merged with the Iron County Steel Co.

the first level only where it has dimensions of at least 450 by 200 feet, second only to the Caspian in area of developed ore. This property looks like the beginning of a very large mine.

The Brule Mining Company has added a considerable tonnage to the reserves of the Chatham Mine by taking over an option on the S. E. ¼ of the N. E. ¼ of Sec. 35, T. 43 N., R. 35 W. The ore body was located at depth in the south part of this description by the Cleveland Cliffs Iron Co. in 1909. This ore will be mined through the Chatham shaft.

Explorations conducted by W. H. Selden in the summer of 1911 in the N. E. ¼ of the S. E. ¼ of Sec. 34, T. 34 N., R. 35 W. known as the Manhattan, resulted in the discovery of an ore body, the dimensions of which are not yet known. The property has been leased by the Wickwire Mining Co. and a small shipment of ore was made in the fall of 1911. Exploration and development work is going rapidly forward. The ore body is on a belt of iron formation which strikes north of west into the middle of section 34, and in the opposite direction swings apparently southeast and then northeast into the North Hiawatha property where exploratory work was conducted by Mr. Selden in 1911.

North of Iron River very important developments have been made in what is known as the James belt. On the Osana (James) property an ore body of very considerable dimensions has been opened on the 4th level near the west end of the mine. The workings extend to within 200 feet of the east line of the adjacent Davidson No. 1 mine, formerly known as the Gleason. On the latter property the New York State Steel Co. is developing an ore body of considerable dimensions and north of it on the southern part of the S. E. ¼ of the S. W. ¼ of Sec. 14, the Jones-Laughlin interests have developed a large tonnage by drilling. The ore here seems to extend eastward into Davidson No. 2 and westward across the S. E. corner of S. W. ¼ of the S. W. ¼ of the section where a small tonnage of ore has been shown by exploration conducted by the Wickwire Mining Co. The ore formation continues apparently southwestward and westward across the Donahue and McGovern leases of the Munroe Mining Co., into the middle of the W. ¼ of the N. E. ¼ of Section 22 where the Iron River Ore Co. is reported to have encountered ore in drilling in the fall of 1911. This latter reported discovery I have, however, not verified. The results of exploration on the James belt during the past two years indicates that it contains a large tonnage of marketable ore. Developments are being rapidly pushed on the Davidson No. 1 and Davidson No.

2 and the Jones-Laughlin property, but steps have not yet been taken to open the deposits known to exist westward on this belt.

From the Osana (James) mine the belt extends east into the Spies exploration.

South of the James belt and striking about parallel to it through the middle of section 23 is an ore bearing formation on which the Mineral Mining Company has opened a very promising exploration known as the Wauseca, formerly the Konwinski. A considerable tonnage of ore has already been opened and the prospects are so favorable as to lead Mr. J. R. Finlay to place the expected tonnage at one million. The iron formation apparently dips steeply to the south between slate walls. Drilling east and south of the Wauseca location by the Republic Iron and Steel Co. is reported to have shown promising results and the property has been leased for mining.

From the Osana (James) Mine the ore-bearing belt extends east into the Spies exploration in the N. W. 1/4 of the N. W. 1/4 of Sec. 24, and possibly eastward across the north part of this section to the Hall exploration of the Bates Mining Co. in the N. 1/2 of the N. W. 1/4 of Sec. 19, 43 N., 34 W. The latter property has been explored by drilling and shaft sinking is now in progress.

The ore-bearing belt extending diagonally northeastward through the center of Sec. 29 and into the S. W. 1/4 of Sec. 21, T. 43 N., R. 34 W. will be first opened on the Rogers location (N. E. 1/4 of Sec. 29) by the Munro Mining Co. The sinking of the Rogers concrete drop shaft during the summer of 1911 was a notable piece of construction work, the first of its kind to be undertaken in this district. Following the successful experience of the Cleveland Cliffs Iron Company in dropping concrete shafts through deep, wet overburden in the Gwinn district, the Munro Mining Co. in 1911 introduced the first concrete drop shaft in the Iron River district. The shaft was started in February and completed in July, the work being done under contract by the Foundation Company of New York. The shaft was dropped through 140 feet of glacial drift. It is circular, 29 feet in diameter with rectangular compartment 16 1/2 ft. by 11 ft., divided into pipe and ladder way, cage road, and a double skip road. The main advantages of the concrete shaft are its dryness, stability, and permanency. It is expected that similar conditions on other undeveloped properties will increase the number of concrete shafts in the Iron River district.

The Chicago Mine in the N. W. 1/4 of the N. E. 1/4 of Sec. 26, 43-34 which was the scene of one of the earliest explorations in the

Iron River district, after a long period of persistent exploration by the Munro Mining Company, has been brought to a producing stage. The first shipments from this mine were sent out in the summer of 1911 over the recently completed spur of the Chicago and Northwestern Railroad from the main line about two miles east of Saunders. The strike of the ore formation in the Chicagon mine is about N. E. and S. W. The formation lies on a black slate wall, dipping S. W. at an angle of about 70 degrees. Black slate also occurs on the hanging walls. As measured on a cross section at a depth of 480 feet the iron formation is between 400 and 500 feet thick, making no allowance for folding. The ore body, from which shipments are being made, has been opened up on the 5th or 500 foot level. In the development of the body thus far, reserves totaling in the neighborhood of 400,000 tons are known to exist above this level.

It is thought probable that the ore bearing formation of the Chicagon Mine is at the same horizon as that of the Rogers Mine and may possibly be connected directly with the latter through the S. ½ of Secs. 21, 22 and 23. Some drilling is being done along this hypothetical line by the Cleveland Cliffs Iron Co., but results are not yet available for publication.

In the above paragraphs there has been outlined the more important developments which have been made in the last couple of years. Stagnation in the iron market during 1911 had no appreciable effect on exploratory activity in the Iron River district and from all indications the work of exploration will go steadily forward for some time to come. A large number of strong competing interests have secured a foothold in the district. Notwithstanding, the difficulties inherent in prospecting a drift covered field, the Iron River district offers in the proved richness of the ore bearing formation and the successful outcome of many recent operations, one of the most attractive areas for exploration in the Lake Superior region.

GOGEBIC DISTRICT.

The Gogebic iron district extends from Lake Gogebic westward to the Montreal River and is prolonged southwestward in Wisconsin to near Lake Numakagon under the name of Penokee range. Its total length is about eighty miles. In earlier years the name Agogebic was applied to the Michigan portion. In contrast to the history of other iron ranges the Gogebic was known and geologically mapped prior to the opening of ore deposits. The simplicity of rock structure and succession of strata combined with the topographic prominence of the range and the magnetism of the iron formation made possible early accurate geologic mapping. No ore discoveries have been made outside the limits of the iron formation thus early determined.

The earlier explorations were made on the western (Wisconsin) end of the range on the more highly magnetic and better exposed parts of the iron formation. The years immediately following the opening of the range in 1884 were marked by a frenzy of speculation. The companies formed in 1886 alone had a total capitalization of above $1,000,000,000.00.[11] In the crash that followed in 1887 the small investor was squeezed out, but some of the stronger companies survived and formed a neucleus which kept the work of exploration and development moving while business conditions were being readjusted. Despite the collapse of the speculative craze the production rose steadily from 1884, reaching a mark in 1892 that was not reattained until a decade later, 1902. The production curve is plotted in Fig. 11.

The district is served by the Duluth, South Shore and Atlantic Ry., the Wisconsin Central which crossed the range at Penokee Gap in 1873, extending a branch to the center of the district in 1887, and the Chicago and Northwestern Ry. which reached Ironwood from the Menominee Range in 1882 and made connections with Ashland in 1885.

The Ore Deposits: The ore deposits are confined to the central part of the range extending from near Iron Belt in Wisconsin to Sunday Lake in Michigan, though ore is known on Secs. 15 and 21, T. 47 N., R. 43 W. west of Gogebic Lake. Up to 1910 Michigan had produced about 84% of the total output.

The important factors affecting the formation of the ore deposits are (1) the steeply inclined position of the iron formation, which limits the exposed part to a belt not greatly in excess of its thickness and favors great vertical component for the ore bodies compared to horizontal section. The ore deposits occupy only about 1 per cent of the area of the exposed iron formation.[12] (2) The underlying impervious quartzite dipping northward forms the footwall of the majority of the ore bodies and in many cases forms with (3) impervious basic dikes, which cut the bedding of the Huronian series at an average 90° angle, natural troughs, pitching usually gently eastward but in some cases westward, carrying the great

[11] Mon. 52, U. S. Geological Survey.
[12] Mon. 52, U. S. Geological Survey, p. 235.

ore deposits of the district. The ore deposits are generally best developed in the troughs thus formed extending upward along either or both limbs of the trough and following it downward along the pitch. The number of such pitching troughs on a given cross section is limited only by the number of intersecting dikes, and sections through many properties exhibit several ore bodies lying one above another each bottomed in a trough formed by the intersection of a dike with the footwall quartzite. The dikes vary up to about a hundred feet in thickness. (4) Interbedded slate or quartzite may function as a footwall carrying ore bodies in horizons which are far above the underlying Palms quartzite. (5) Minor structures such as bedding, brecciation and faulting serve as guides to downward moving water, and are thus favorable to secondary concentration. Some or all of these factors are operative in every instance in localizing ore bodies and in some cases are apparently alone adequate to induce alteration to ore. (6) Certain horizons in particular places were originally above average richness requiring less concentration to form ore bodies. This factor is believed to have been important in those places where ore bodies exist in the absence of structural conditions particularly inducive to secondary concentration, as at the Mikado, Brotherton and Sunday Lake mines.[13]

DEVELOPMENT.

As stated above no ore has been found outside the limits of the Ironwood formation as mapped prior to 1884. Exploratory work on the Gogebic Range is therefore not of necessity first directed toward locating the iron bearing rocks as in some other districts particularly the Iron River, Crystal Falls, and Gwinn areas but proceeds more directly to the opening of promising parts of the ore bearing formation. The methods employed elsewhere are used on the Gogebic but diamond drilling is carried on to less extent. In the working properties much attention has been directed to exploration at greater depths following the lead of Mr. J. R. Thompson whose persistent efforts revealed at the Newport, a large body of high grade ore at a depth of 2,000 feet and over. The proved occurrence of ore at great depth will prolong indefinitely the life of many properties on the Gogebic range. Whereas only a few years ago there was considerable apprehension among geologists and engineers regarding the existence of rich iron ores at any-

[13]Mon. 52, United States Geological Survey.

thing over moderate depths, there is now a strong presumption that ores will be found at depths greater than that of the Newport deposit, possibly to the lower limits of profitable mining.

ORE RESERVES.

The tonnage of ore reserves reported to the Michigan State Tax Commission in 1911 is given below:

ORE RESERVES, GOGEBIC RANGE, 1911.

	Reported in sight by company.	Total tonnage expected. Estimates by J. R Finlay.
Ashland	197,000	200,000
Norrie-Aurora	9,361,500	18,000,000
Newport	5,475,000	16,000,000
Puritan	50,000	100,000
Ironton	130,000	500,000
Yale	....	1,000,000
Colby	815,800	1,500,000
Tilden	404,500	1,000,000
Anvil and Palms	379,000	1,000,000
Eureka	65,000	200,000
Asteroid	10,000	....
Mikado	20,000	500,000
Chicago	184,000	500,000
Brotherton	995,000	1,000,000
Sunday Lake	150,000	1,500,000
Castile	1,000	....
Total	17,338,800	43,000,000

MARQUETTE RANGE.

The Marquette district is the oldest of the iron districts of the Lake Superior region. It had been producing ore for 24 years prior to the opening of the Menominee district in 1872. The first discovery of iron ore in the Marquette district and the Lake Superior Region was made in 1844 at the site of the old Jackson mine at Negaunee by a U. S. land surveying party under charge of W. A. Burt who was working under Dr. Douglass Houghton, the first state geologist of Michigan. Lack of space forbids a sketching of the long and interesting history of the Marquette district. It is interesting to note that a large number of the important mines now worked in the Marquette district were opened prior to 1872, although very important discoveries have been made since that time, particularly in recent years.

RECENT DEVELOPMENTS.

The Marquette district, which has produced iron ore since 1848 or for 63 years, and in this time has sent to market 93,749,928 tons (to 1911) has an available estimated reserve of 75,977,006 tons (1911) of marketable ore or 80% of total shipments. There is more ore in sight today than ever before, a fact which illustrates in striking manner the relative permanency of the iron mining industry. Recent deep drilling in bottom horizons of the Negaunee formation "suggests that the beds of this horizon at great depths may ultimately be found to carry a larger tonnage of ore than those of any of the other horizons,"[14] a matter of transcendant importance to the future of the district. On the Marquette as well as in the Gogebic district development at great depth has changed what was formerly a hope into a practical certainty, viz., that deeply buried portions of the iron formation are ore-bearing and are likely to be fully as productive as the shallower parts.

The area underlain by the iron-bearing formations has long been known and appears on accurate maps of the U. S. Geological Survey. Explorers may therefore proceed to the opening of promising parts of the iron formation without necessity of first locating the formation itself as is necessary in the drift covered and less accurately mapped areas. In recent years there have been relatively fewer new explorations on the Marquette range than in the Crystal Falls and Iron River districts. This is not surprising in an area where the data of many years has thrown more light on the ore bearing possibilities of different localities. In other words, exploration on the Marquette range does not now of necessity proceed in many cases blindly but on the contrary with considerable assurance regarding the geological conditions expected to prevail. The stronger companies which operate in the district are well fortified with reserve tonnage and land holdings and in contrast with the conditions in the Crystal Falls and Iron River districts, in the main producing localities have neither the same necessity nor the opportunity to compete for new acquisitions. The field is an old one and partition of interests was practically established long ago.

Important construction work has been under way by the Cleveland Cliffs Iron Co. A new concrete shaft was sealed to ledge at the Maas mine in September, 1911. The concrete work is circular, 200 feet deep with rectangular open-

[14]Mon. 52, U. S. Geological Survey.

ing 11 ft. 2 in. by 15 ft. 2 in. inside including a pipe and ladder way, one cage and two skip roads. A similar shaft was constructed at the Negaunee mine. The most important recent work undertaken by this company, however, is the installation of an hydro-electric power system, the largest project of its kind ever undertaken in the Michigan mining regions.

The Carp river is to be harnessed through a plant of two 4,000 H. P. units equipped for 60,000 volts, located just opposite the state prison near Marquette, driven by a fall of 600 feet on a 25% grade from a stand pipe one-half mile distant on the top of Mt. Mesnard. The dam is four miles up stream from the power house. It is 50′ wide at the base and 120′ in length. From the dam the water will be conveyed through a 22,000′ line of pipe 66″ in diameter, 12,000 feet of steel and 10,000′ of Washington fir staves. The power will be conveyed from the generating station over a double circuit transmission line some 36 miles long to the company's mines at North Lake, Ishpeming, Negaunee and the Gwinn district. The cost of the installation is estimated at about $1,000,000.00.

Four new mines should be added to the producing list in 1912, viz., the Maitland, Morris (North Lake No. 1), Lloyd (North Lake No. 2) and the Chase (Barnes). During 1910 and 1911 work has gone steadily forward at the three latter properties. Steel headframes have been erected and the ore deposits partially opened up. The Maitland is a new property of the Volunteer Ore Co. located at the east end of Palmer Lake. The shaft is down about 300 feet and a soft ore body of high grade partially developed.

Another event of importance is the installation of the Ardis furnace at the old Kloman mine for the treatment of low grade ores by the Jones Step Process. The problem of the utilization of low grade ores is an important one and we have, therefore, chosen to give separate and detailed treatment of the Jones Step Process in a separate chapter.

ORE RESERVES.

The tonnage of ore reserves on the Marquette range as reported by J. R. Finlay to the Michigan State Tax Commission is given below.

ORE RESERVES, MARQUETTE DISTRICT, 1911.

Mine.	Reported in sight above bottom level.	Total tonnage expected by J. R. Finlay.
Lillie	72,651	72,651
Cambria (Old Hartford)	825,000	825,000
Mary Charlotte No. 1 and No. 2	1,500,000	2,775,000
Breitung Hematite No. 1 and No. 2	250,000	2,000,000
Lake Angeline-Mitchell	430,000	475,000
Rolling Mill	1,152,177	1,500,000
Lake	3,707,110	3,707,000
Negaunee	13,635,200	13,635,000
Salisbury	584,000	584,000
Mass	9,662,400	9,662,000
Lake Superior Soft Ore	2,250,000	4,000,000
Queen	1,893,000	1,900,000
Race Course	....	1,500,000
Lucky Star	....	4,000,000
Harvey Lots	....	4,000,000
North Range	....	1,510,000
Republic	1,358,000	2,000,000
Washington	....	....
Barron	310,000	432,000
Franklin	....	....
American Boston (not reported)	....	500,000
Volunteer	30,000	150,000
Lake Superior Hard Ore	1,470,000	2,270,000
Section 16	5,311,355	9,446,355
Champion	1,625,000	2,825,000
Cliff Shaft	2,167,000	2,500,000
Moro	50,000	50,000
North Lake 6-47-27	....	594,000
Imperial	1,500,000	1,500,000
Ohio	117,100	317,000
Portland	247,085	247,000
Total	50,147,078	75,977,006

GWINN (SWANZY) DISTRICT.

The Gwinn district lies south of the Marquette range in T. 45 N., R. 25 W. It is served by the Chicago and Northwestern Ry. and the Munising Ry. The district has produced more or less steadily from the old Swanzy (Princeton) Mine since 1872. Development work of the last decade has brought the district rapidly into prominence. The Stephenson and Austin made first shipments in 1907, the Stegmiller in 1909. The Smith began hoisting in September, 1911, and concrete shafts are sealed to ledge on the Kidder and Northwestern. The district is controlled with the exception of the Stegmiller mine which is operated by the Oliver Iron Mining Co., by the Cleveland Cliffs Iron Co., by whom active exploration has been conducted since 1902. Electric power will be supplied by the Cleveland Cliffs Iron Co. transmission line from their plant on Carp River near Marquette.

Probably the most attractive mining town in the Lake Superior Region is the village of Gwinn, planned and built by the Cleveland Cliffs Iron Co. The only natural advantage is its situation on the Escanaba river which affords good drainage and a sewage outlet. The village is laid out on a beautiful plan with ample parks. A fine commodious school building, an excellent club house for employes of the company and a good hotel are noteworthy features, while the general cleanliness and cheerfulness of appearance of both business and residence portions of the village is indeed refreshing to the visitor as it must be to the residents. The company, whose skill, energy and foresight has created an industry which supports a growing community with modern provisions for human comfort and sanitation where lately was a jack pine sand plain should be commended and congratulated.

GEOLOGY.

The Gwinn district forms a southeastward pitching synclinorium of Upper Huronian rocks about 2 miles long and ½ to ¾ of a mile wide, widening to the southeast where the structure is lost beneath deep overburden. In other directions the district is surrounded by hills of Archean granite.

The Upper Huronian rocks lie unconformably on the Archean granite and comprise two distinct formations, viz., the Goodrich quartzite, which at the base is a recomposed granite or arkose grading upward through quartzite and quartz slate into the Bijiki iron-bearing member, and the Michigamme slate series in which the Bijiki formation is included. The Goodrich quartzite is absent in places thus bringing the slate or iron formation into contact with the underlying granite.

Flat lying Paleozoic limestones and sandstones overlap to the east, the older formations of the Gwinn district. (See fig. 10.)

ORE RESERVES.

Probably the most attractive mining town in the Lake Superior Region is the village of [illegible]

ORE RESERVES.

The ore reserves of the district as reported to the State Tax Commission by J. R. Finlay in 1911 are given below:

ORE RESERVES, GWINN DISTRICT, 1911.

Mine.	Reported in sight above bottom level.	Total tonnage expected by J. R. Finlay.
Stegmiller	246,000	266,000
Princeton No. 1 and No. 2	1,157,317	1,057,000
Austin	503,774	503,774
Stephenson	780,646	780,646
Smith	952,727	952,727
Sec. 19, 45-25 N. E. ¼ of N. E. ¼	....	54,143
Sec. 45-25 lots 2 and 3	....	523,339
Sec. 27, 45-25 S. W. ¼ and S. W. ¼ of N. W. ¼	....	345,203
Kidder	....	646,071
Sec. 29, 45-25 N. ½ of N. W. ¼	....	246,800
Sec. 35, 45-25 S. E. ¼ of S. E. ¼	....	453,425
Sec. 35, 45-25	....	916,130
	3,640,464	6,746,158

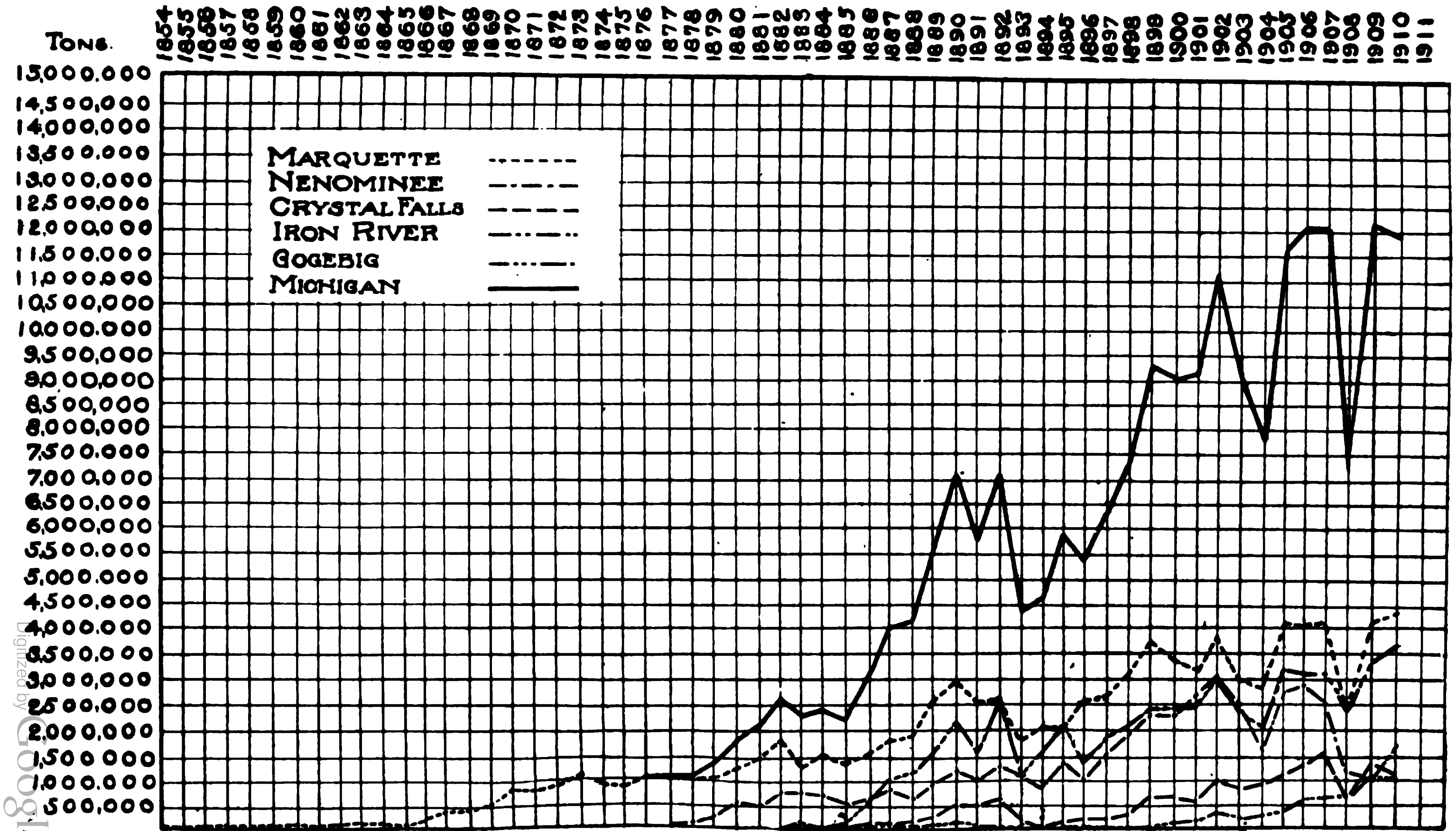

Fig. 11. Production curves for Michigan Iron Ranges.

SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS)

Range.	1880 and prior years.	1881.	1882.	1883.	1884.
Marquette	13,849,627	1,564,823	1,797,896	1,291,695	1,554,477
Gwinn	79,840	15,011	31,498	13,730	3,557
Menominee	943,535	541,724	756,594	712,150	663,425
Crystal Falls	....	....	42,111	70,866	66,175
Iron River	....	....	31,595	129,590	90,204
Gogebic	....	....	....	....	1,022
Metropolitan	....	....	23,854	43,845	37,581
Calumet	....	....	5,847	29,239	3,627
Total	14,873,002	2,121,558	2,689,395	2,291,115	2,420,068
	1885.	1886.	1887.	1888.	1889.
Marquette	1,430,362	1,619,052	1,848,792	1,923,667	2,642,813
Gwinn	....	8,328	2,142	....	....
Menominee	567,805	592,443	786,244	637,182	947,124
Crystal Falls	23,990	185,680	172,665	230,282	314,229
Iron River	55,693	86,366	116,006	115,744	180,340
Gogebic	114,393	658,951	1,069,409	1,249,415	1,575,989
Metropolitan	....	6,393	9,070	3,490	....
Calumet	....	....	....	....	....
Total	2,192,243	3,157,213	4,004,328	4,159,780	5,660,495
	1890.	1891.	1892.	1893.	1894.
Marquette	2,993,663	2,504,941	2,637,453	1,816,797	2,060,260
Gwinn	....	7,301	29,403	19,096	....
Menominee	1,233,700	1,053,772	1,338,659	1,128,238	866,804
Crystal Falls	527,038	504,928	603,048	220,969	37,515
Iron River	159,494	81,082	46,921	3,917	....
Gogebic	2,230,395	1,601,266	2,510,945	1,228,138	1,668,729
Metropolitan	....	1,049	....	....	....
Calumet	....	....	....	....	....
Total	7,144,290	5,754,339	7,166,429	4,417,155	4,633,308
	1895.	1896.	1897.	1898.	1899.
Marquette	2,091,245	2,604,221	2,715,035	3,099,792	3,701,208
Gwinn	6,593	....	....	25,247	55,802
Menominee	1,471,543	1,139,996	1,516,004	1,816,638	2,348,205
Crystal Falls	202,600	288,209	284,986	356,268	716,971
Iron River	17,955	3,419	146	5,009	44,346
Gogebic	2,126,090	1,434,006	1,865,130	2,072,356	2,441,053
Metropolitan	....	....	....	....	....
Calumet	....	....	....	....	....
Total	5,916,026	$5,469,851	6,381,301	7,375,310	9,307,585

SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS)

(Continued.)

	1900.	1901.	1902.	1903.	1904.
Marquette	3,382,495	3,178,295	3,749,977	2,956,022	2,767,242
Gwinn	75,037	67,051	118,048	84,223	76,461
Menominee	2,312,779	2,660,030	3,001,189	2,528,819	1,712,800
Crystal Falls	720,066	696,844	1,003,785	824,461	917,969
Iron River	139,278	157,541	355,110	276,785	284,273
Gogebic	2,422,454	2,419,144	3,018,255	2,465,263	2,042,398
Metropolitan	....	11,444	8,923	18,574	4,737
Calumet	....	....	....	....	....
Total	9,072,109	9,190,349	11,255,287	9,154,147	7,805,880

	1905.	1906.	1907.	1908.	1909.
Marquette	4,086,493	3,935,293	3,907,955	2,214,782	3,983,436
Gwinn	129,079	166,894	380,118	199,850	272,736
Menominee	2,741,169	2,953,131	2,498,784	1,254,110	1,991,108
Crystal Falls	1,174,366	1,395,910	1,631,484	629,602	1,425,261
Iron River	337,973	568,469	589,946	630,745	1,152,076
Gogebic	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415
Metropolitan	....	....	13,913	9,123	24,933
Calumet	....	15,773	51,646	15,222	....
Total	11,684,432	12,149,451	12,166,929	7,302,060	12,251,965

	1910.	Total.
Marquette	3,840,129	93,749,928
Gwinn	552,597	2,419,642
Menominee	1,674,447	46,390,151
Crystal Falls	1,206,592	16,474,870
Iron River	1,001,960	6,661,983
Gogebic	3,652,918	55,061,176
Metropolitan	26,462	243,391
Calumet	....	121,354
Total	11,955,105	221,122,495

SUMMARY

Marquette .
Gwinn. . . . .
Menominee.
Crystal Fall
Iron River .
Gogebic. . . .
Metropolita
Calumet . . .
Total. .

Marquette .
Gwinn. . . . .
Menominee.
Crystal Fall
Iron River .
Gogebic. . . .
Metropolita
Calumet ..
Total.

Marquette .
Gwinn . . . .
Menominee
Crystal Fal
Iron River.
Gogebic . . .
Metropolita
Calumet . . .
Total .

SHIPMENTS OF IRON ORE FROM MICHIGAN RANGES BY COUNTIES.
(GROSS TONS.)

County.	1890 and prior years.	1891.	1892.	1893.	1894.
Gogebic	6,899,574	1,601,266	2,510,945	1,228,138	1,668,729
Iron	2,598,068	586,010	649,969	224,886	37,515
Dickinson	8,547,872	1,054,821	1,338,659	1,128,238	866,804
Marquette	32,542,296	2,493,690	2,659,662	1,835,893	2,060,260
Baraga	128,677	18,552	7,194	....	....
Total	50,716,487	5,754,339	7,166,429	4,417,155	4,633,308
	1895.	1896.	1897.	1898.	1899.
Gogebic	2,126,090	1,434,006	1,865,130	2,072,356	2,441,053
Iron	220,555	291,628	285,132	361,277	761,317
Dickinson	1,471,543	1,139,996	1,516,004	1,816,638	2,348,205
Marquette	2,097,838	2,604,221	2,715,035	3,125,039	3,733,775
Baraga	....	....	....	....	23,235
Total	5,916,026	5,469,851	6,381,301	7,375,310	9,307,585
	1900.	1901.	1902.	1903.	1904.
Gogebic	2,442,454	2,419,144	3,018,255	2,465,263	2,042,398
Iron	859,344	854,385	1,358,895	1,101,246	1,202,242
Dickinson	2,312,779	2,671,474	3,010,112	2,547,393	1,717,537
Marquette	3,393,618	3,241,008	3,808,244	2,905,597	2,817,195
Baraga	63,904	4,338	59,781	134,648	26,508
Total	9,072,099	9,190,349	11,255,287	9,154,147	7,805,880
	1905.	1906.	1907.	1908.	1909.
Gogebic	3,215,352	3,113,981	3,093,083	2,348,626	3,402,415
Iron	1,512,339	1,964,379	2,221,430	1,260,347	2,577,337
Dickinson	2,741,169	2,968,904	2,564,343	1,278,455	2,016,041
Marquette	4,175,605	4,097,111	4,154,288	2,305,366	3,888,055
Baraga	39,967	5,076	133,785	109,266	368,117
Total	11,684,432	12,149,451	12,166,929	7,302,060	12,251,965
					1910.
Gogebic					3,652,918
Iron					2,208,552
Dickinson					1,700,909
Marquette					4,236,311
Baraga					156,415
Total					11,955,105

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.[1]

	1884.	1885.	1886.	1887.	1888.
Ada (included in Ironton)					
Anvil				10,075	24,676
Ashland		6,741	74,015	175,563	174,183
Aurora		5,422	94,553	159,253	179,937
Bessemer			4,788	16,101	
Blue Jacket				1,799	
Brotherton			8,880	21,721	40,639
Castile					
Chicago					
Colby	1,022	84,303	257,432	258,518	285,880
Davis (Wisconsin)					
Eureka					
Federal					
First National				1,997	
Geneva					
Imperial (see Federal)					
Iron Chief			9,950	2,249	
Iron Chief No. 2			551		
Iron King (see Newport)					
Ironton			18,424	24,762	
Jack Pot					
Meteor (Comet)					
Mikado					
New Davis (see Davis)					
Newport			20,184	75,660	69,145
Norrie Group		15,419	124,844	237,254	412,196
Pabst		1,103	17,979	19,906	49,976
Palms				1,414	9,725
Pike					
Puritan (Ruby)			16,388	45,000	3,058
Sparta					
Sunday Lake		1,405	10,963	18,137	
Tilden					
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)					
Total	1,022	114,393	658,951	1,069,409	1,249,415

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1889.	1890.	1891.	1892.	1893.
Ada (included in Ironton)	....	....	....	....	....
Anvil	47,000	73	42,090	....	....
Ashland	257,915	435,949	267,439	231,896	66,067
Aurora	199,865	246,695	83,554	319,482	179,028
Bessemer	....	....	....	....	....
Blue Jacket	....	....	....	....	....
Brotherton	53,267	80,486	46,574	130,833	18,905
Castile	....	....	....	....	....
Chicago	....	....	....	....	....
Colby	136,833	193,038	9,619	69,968	59,346
Davis (Wisconsin)	....	1,497	....	21,754	15,210
Eureka	....	23,794	13,907	10,655	31,385
Federal	....	21,150	6,778	8,515	....
First National	....	....	....	....	....
Geneva	....	....	....	....	....
Imperial (see Federal)	....	....	....	....	....
Iron Chief	....	....	....	....	....
Iron Chief No. 2	....	....	....	....	....
Iron King (see Newport)	....	....	....	....	....
Ironton	8,635	6,247	300	....	....
Jack Pot	....	....	....	3,944	1,651
Meteor (Comet)	....	2,882	10,144	54,779	9,604
Mikado	....	....	....	....	....
New Davis (see Davis)	....	....	....	....	....
Newport	36,987	71,488	105,606	165,962	109,718
Norrie Group	674,394	906,728	758,572	985,216	472,062
Pabst	116,376	172,060	130,226	113,245	104,510
Palms	35,245	50,604	32,227	102,382	2,658
Pike	....	....	....	....	....
Puritan (Ruby)	9,472	11,694	913	....	....
Sparta	....	....	....	2,912	....
Sunday Lake	....	6,010	64,902	56,046	22,876
Tilden	....	....	28,415	233,356	135,118
Vaughn (see Aurora)	....	....	....	....	....
Wisconsin (see Davis)	....	....	....	....	....
Yale (West Colby)	....	....	....	....	....
Total	1,575,989	2,230,395	1,601,266	2,510,945	1,228,138

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1894.	1895.	1896.	1897.	1898.
Ada (included in Ironton)					
Anvil	13,297	68,064	57,483		5,037
Ashland	83,020	126,096	91,149	111,625	123,208
Aurora	203,152	245,883	187,169	166,122	133,076
Bessemer					
Blue Jacket					
Brotherton	47,148	40,567	50,490	46,186	73,198
Castile					
Chicago			504		
Colby	32,616		48,492	22,921	152,875
Davis (Wisconsin)		10,253			
Eureka	18,329	26,105	4,544		
Federal					
First National					
Geneva					
Imperial (see Federal)					
Iron Chief					
Iron Chief No. 2					
Iron King (see Newport)					
Ironton					
Jack Pot				1,265	
Meteor (Comet)	11,782				
Mikado		4,788		11,397	
New Davis (see Davis)					
Newport	150,392	157,821	142,369	150,979	196,953
Norrie Group	621,608	738,480	329,068	604,281	700,990
Pabst	206,074	219,960	68,984	220,496	223,891
Palms	37,911	46,965	114,108	207,153	175,925
Pike					
Puritan (Ruby)					
Sparta		1,950			
Sunday Lake	34,323	20,970	89,441	45,815	
Tilden	209,077	418,188	250,205	276,890	287,203
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)					
Total	1,668,729	2,126,090	1,434,006	1,865,130	2,072,356

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1899.	1900.	1901.	1902.	1903.
Ada (included in Ironton)	......	......	......	......	......
Anvil	......	......	101	135,502	11,309
Ashland	154,615	232,961	286,399	301,824	274,138
Aurora	170,369	193,111	223,747	402,981	355,365
Bessemer	......	......	......	......	......
Blue Jacket	......	......	......	......	......
Brotherton	78,858	89,804	103,109	53,255	94,986
Castile	......	......	......	......	......
Chicago	......	633	......	44,625	22,965
Colby	103,239	32,572	23,475	22,526	54,915
Davis (Wisconsin)	5,029	3,569	......	31,530	734
Eureka	......	......	......	......	......
Federal	......	......	......	......	......
First National	......	......	......	......	......
Geneva	......	......	......	......	7,108
Imperial (see Federal)	......	......	......	......	......
Iron Chief	......	......	......	......	......
Iron Chief No. 2	......	......	......	......	......
Iron King (see Newport)	......	......	......	......	......
Ironton	7,977	25,047	......	8,555	16,875
Jack Pot	......	33,893	19,988	102	31,709
Meteor (Comet)	332	7,844	34,140	19,117	6,156
Mikado	10,324	1,090	91,846	98,834	108,709
New Davis (see Davis)	......	......	......	......	......
Newport	263,711	217,201	190,448	141,571	279,905
Norrie Group	714,669	666,389	660,965	1,080,032	790,346
Pabst	263,869	239,242	198,686	......	......
Palms	154,705	139,658	7,603	32,113	60,800
Pike	......	3,434	6,346	6,343	115
Puritan (Ruby)	......	......	21,788	......	......
Sparta	......	......	......	......	......
Sunday Lake	12,526	74,097	89,997	144,630	91,383
Tilden	500,830	481,909	446,670	468,672	211,534
Vaughn (see Aurora)	......	......	......	......	......
Wisconsin (see Davis)	......	......	......	......	......
Yale (West Colby)	......	......	12,836	26,043	46,211
Total	2,441,053	2,442,454	2,419,144	3,018,255	2,465,263

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1904.	1905.	1906.	1907.	1908.
Ada (included in Ironton)					
Anvil	45,595	82,118	79,493	39,495	35,937
Ashland	344,102	409,131	341,841	298,056	259,611
Aurora	212,920				
Bessemer					
Blue Jacket					
Brotherton	84,870	137,351	147,281	104,224	96,776
Castile			2,108	6,157	
Chicago					
Colby	81,141	83,736	113,001	94,480	58,305
Davis (Wisconsin)	11,225	3,160			
Eureka			37,525	57,904	122,324
Federal					
First National					
Geneva					
Imperial (see Federal)					
Iron Chief					
Iron Chief No. 2					
Iron King (see Newport)					
Ironton	23,197	41,314	106,158	190,968	92,932
Jack Pot	6,538				
Meteor (Comet)	59,589				
Mikado	25,611	140,740	154,043	163,891	86,617
New Davis (see Davis)					
Newport	171,931	438,023	549,745	551,496	579,390
Norrie Group	618,638	1,527,128	1,245,997	1,109,085	773,243
Pabst					
Palms	53,718	13,953	5,622		
Pike		11,161	17,934	24,922	6,303
Puritan (Ruby)	1,259				
Sparta					
Sunday Lake	50,625	79,209	86,879	101,899	111,130
Tilden	204,581	188,104	169,697	312,496	111,184
Vaughn (see Aurora)					
Wisconsin (see Davis)					
Yale (West Colby)	46,860	60,224	56,657	38,010	14,874
Total	2,042,398	3,215,352	3,113,981	3,093,083	2,348,626

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1909.	1910.	Total.
Ada (included in Ironton)	....	....	....
Anvil	22,927	7,235	728,507
Ashland	259,612	231,506	5,618,662
Aurora	....	....	3,961,684
Bessemer	....	....	20,889
Blue Jacket	....	....	1,799
Brotherton	103,090	102,626	1,855,124
Castile	26,982	20,197	55,444
Chicago	....	....	68,727
Colby	170,095	194,754	2,645,102
Davis (Wisconsin)	....	....	103,961
Eureka	115,662	41,611	503,745
Federal	....	....	36,443
First National	....	....	1,997
Geneva	....	....	7,108
Imperial (see Federal)	....	....	....
Iron Chief	....	....	12,199
Iron Chief No. 2	....	....	551
Iron King (see Newport)	....	....	....
Ironton	277,594	109,025	958,910
Jack Pot	....	....	99,090
Meteor (Comet)	....	....	216,367
Mikado	99,195	52,715	1,049,800
New Davis (see Davis)	....	....	....
Newport	1,008,354	1,182,324	7,027,363
Norrie Group	977,054	1,333,006	19,077,664
Pabst	....	....	2,366,583
Palms	....	....	1,284,489
Pike	22,174	3,324	102,056
Puritan (Ruby)	....	50,019	159,591
Sparta	....	....	4,862
Sunday Lake	93,712	115,486	1,422,461
Tilden	154,506	99,937	5,188,572
Vaughn (see Aurora)	....	....	....
Wisconsin (see Davis)	....	....	....
Yale (West Colby)	71,458	108,253	481,426
Total	3,402,415	3,652,918	55,061,176

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.[1]

	1877.	1878.	1879.	1880.	1881.
Antoine					
Aragon					
Breen	5,812	4,796	1,463	5,359	
Briar Hill					
Chapin				34,556	134,521
Clifford					
Cornell				30,856	11,816
Cuff					
Cundy					
Curry			12,803	21,851	17,534
Cyclops		6,028	46,158	14,368	12,644
Eleanor (Appleton)					
Emmett		12,397	22,474	31,136	648
Forest					
Half and Half					
Hamilton					
Hersel					
Indiana					
Keel Ridge				11,496	19,511
Loretto					
Ludington				8,816	3,374
Millie (Hewitt)					4,352
Munro					
Norway		7,276	73,519	198,165	137,077
Penn Iron Mining Co					
Perry					
Pewabec					
Quinnesec		25,925	41,954	52,436	43,711
Saginaw (Perkins)			13,465	49,196	60,406
Stephenson			798	23,089	10,856
Sturgeon River					
Verona					
Vivian					
Vulcan	4,593	38,799	56,975	86,976	85,274
Walpole					
Total	10,405	95,221	269,609	568,300	541,724
Metropolitan Trough.					
Groveland					
Metropolitan					
Northwestern					
Total					
Calumet Trough.					
Calumet					

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1882.	1883.	1884.	1885.	1886.
Antoine					
Aragon					
Breen					
Briar Hill	10,593	4,388			
Chapin	247,506	265,830	290,972	157,455	198,871
Clifford					
Cornell					4,566
Cuff					
Cundy					
Curry	13,374	3,676	10,079	4,897	
Cyclops	18,287	22,675	24,099	49,897	37,189
Eleanor (Appleton)					
Emmett					
Forest					
Half and Half					
Hamilton					872
Hersel					
Indiana	4,280	4,362	636	2,739	5,854
Keel Ridge	23,425	5,033			
Loretto					
Ludington	52,152	102,632	101,165	124,194	74,454
Millie (Hewitt)	9,500	7,516	7,927	4,627	5,517
Munro					
Norway	165,547	114,836	71,710	67,741	93,878
Penn Iron Mining Co					
Perry		3,138			
Pewabec					
Quinnesec	44,240	21,676	16,995	14,110	13,442
Saginaw (Perkins)	73,648	76,514	38,120	18,020	12,852
Stephenson					1,018
Sturgeon River					
Verona					
Vivian					
Vulcan	94,042	79,874	101,722	124,125	143,930
Walpole					
Total	756,594	712,150	663,425	567,805	592,443
METROPOLITAN TROUGH.					
Groveland					
Metropolitan	23,854	36,643	27,577		6,393
Northwestern		7,202	10,004		
Total	23,854	43,845	37,581		6,393
CALUMET TROUGH.					
Calumet	5,847	29,239	3,627		

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1887.	1888.	1889.	1890.	1891.
Antoine					
Aragon			1,745	46,609	96,829
Breen					
Briar Hill					
Chapin	336,128	290,871	518,990	742,843	488,749
Clifford					
Cornell	2,064				
Cuff					
Cundy					
Curry		5,376	28,722	72,162	100,681
Cyclops	14,297	14,693	6,101	7,361	10,599
Eleanor (Appleton)					
Emmett					
Forest					
Half and Half			5,961	1,496	67
Hamilton	600	8,801	8,347	17,072	58,197
Hersel				955	
Indiana					
Keel Ridge					
Loretto					
Ludington	101,653	61,883	116,297	97,355	141,303
Millie (Hewitt)	1,163	11,124	12,274	39,232	5,889
Munro					
Norway	95,726	87,260	68,044	61,717	4,089
Penn Iron Mining Co					
Perry					
Pewabec				26,991	64,507
Quinnesec	6,585	2,249			
Saginaw (Perkins)	10,834	16,684	12,354	11,971	
Stephenson	3,589				
Sturgeon River	6,827	7,800	4,775		
Verona					
Vivian					
Vulcan	205,036	129,541	153,900	104,996	78,967
Walpole	1,740	900	9,614	2,940	3,895
Total	786,244	637,182	947,124	1,233,700	1,053,772
Metropolitan Trough.					
Groveland					1,049
Metropolitan	9,070	3,490			
Northwestern					
Total	9,070	3,490			1,049
Calumet Trough.					
Calumet					

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1892.	1893.	1894.	1895.	1896.
Antoine	....	....	....	27,931	110,821
Aragon	167,948	127,901	138,209	183,296	95,809
Breen	....	....	....	....	....
Briar Hill	....	....	....	....	....
Chapin	660,052	489,134	235,895	218,589	420,318
Clifford	....	....	....	....	....
Cornell	....	....	....	....	....
Cuff	....	....	....	....	....
Cundy	....	....	....	....	3,395
Curry	125,773	....	....	....	....
Cyclops	1,697	....	....	....	....
Eleanor (Appleton)	4,377	5,618	....	2,107	....
Emmett	....	....	....	....	....
Forest	....	....	....	....	....
Half and Half	....	....	....	....	....
Hamilton	2,183	....	....	....	....
Hersel	....	....	....	....	....
Indiana	....	....	....	....	....
Keel Ridge	5,997	3,298	....	19,441	....
Loretto	8,131	55,983	....	53,160	34,334
Ludington	15,777	109	354	....	....
Millie (Hewitt)	6,780	....	13,062	10,924	21,815
Munro	....	....	....	....	....
Norway	44,767	....	....	....	....
Penn Iron Mining Co	....	280,450	175,274	290,622	179,917
Perry	....	....	....	....	....
Pewabec	115,273	165,745	303,010	262,551	273,587
Quinnesec	....	....	....	761	....
Saginaw (Perkins)	....	....	....	2,161	....
Stephenson	....	....	....	....	....
Sturgeon River	....	....	....	....	....
Verona	....	....	....	....	....
Vivian	....	....	....	....	....
Vulcan	179,904	....	....	....	....
Walpole	....	....	....	....	....
Total	1,338,659	1,128,238	866,804	1,471,543	1,139,996
METROPOLITAN TROUGH.					
Groveland	....	....	....	....	....
Metropolitan	....	....	....	....	....
Northwestern	....	....	....	....	....
Total	....	....	....	....	....
CALUMET TROUGH.					
Calumet	....	....	....	....	....

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1897.	1898.	1899.	1900.	1901.
Antoine	98,847	104,510	93,025	119,940	63,429
Aragon	149,594	295,821	337,807	404,645	477,212
Breen					
Briar Hill					
Chapin	643,402	724,768	940,513	929,937	929,701
Clifford					
Cornell					
Cuff			20,210	38,209	
Cundy	41,942	76,877	100,902	141,148	178,800
Curry					
Cyclops					
Eleanor (Appleton)					
Emmett					
Forest					
Half and Half					
Hamilton					
Hersel					
Indiana					
Keel Ridge			4,900		
Loretto	54,104	68,447	64,824	61,219	54,985
Ludington					
Millie (Hewitt)	10,374	17,430	15,194	14,922	12,133
Munro					
Norway					
Penn Iron Mining Co	237,886	223,713	229,651	197,606	358,126
Perry					
Pewabec	279,855	305,072	530,129	374,043	507,786
Quinnesec			11,050	25,967	66,383
Saginaw (Perkins)					
Stephenson					
Sturgeon River					
Verona				5,143	11,475
Vivian					
Vulcan					
Walpole					
Total	1,516,004	1,816,638	2,348,205	2,312,779	2,660,030
METROPOLITAN TROUGH.					
Groveland					11,444
Metropolitan					
Northwestern					
Total					11,444
CALUMET TROUGH.					
Calumet					

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1902.	1903.	1904.	1905.	1906.
Antoine	110,993	107,886	81,164	138,395	195,855
Aragon	646,203	522,035	374,944	423,698	431,000
Breen				16,625	21,004
Briar Hill					
Chapin	956,812	704,051	541,324	902,628	943,425
Clifford					
Cornell					
Cuff					
Cundy	183,052	111,851			
Curry					
Cyclops					
Eleanor (Appleton)				1,819	3,121
Emmett					
Forest			11,988		
Half and Half					
Hamilton					
Hersel					
Indiana					
Keel Ridge					
Loretto	128,300	87,939	54,720	118,738	140,390
Ludington					
Millie (Hewitt)	25,935	40,860			36,815
Munro		8,739	32,332	92,183	47,451
Norway					
Penn Iron Mining Co	273,443	343,543	141,948	423,244	496,582
Perry					
Pewabec	530,291	489,175	372,791	533,413	493,891
Quinnesec	62,531	49,708	33		
Saginaw (Perkins)					21,017
Stephenson					
Sturgeon River					
Verona	43,245	50,910	20,202		
Vivian	40,384	12,122	81,354	90,426	122,577
Vulcan					
Walpole					
Total	3,001,189	2,528,819	1,712,800	2,741,169	2,953,131
Metropolitan Trough.					
Groveland	7,599	1,294	4,737		
Metropolitan					
Northwestern	1,324	17,280			
Total	8,923	18,574	4,737		
Calumet Trough.					
Calumet					15,773

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1907.	1908.	1909.	1910.	Total.
Antoine	100,996				1,353,792
Aragon	441,636	226,354	246,984	241,046	6,077,325
Breen	20,366				75,425
Briar Hill					14,981
Chapin	855,308	391,620	587,647	465,543	16,647,959
Clifford			103,626	91,081	194,707
Cornell					49,302
Cuff					58,419
Cundy		1,410	5,512		844,889
Curry					416,928
Cyclops					286,093
Eleanor (Appleton)	1,677				18,719
Emmett					66,655
Forest					11,988
Half and Half					7,524
Hamilton					96,072
Hersel					955
Indiana					17,871
Keel Ridge					93,101
Loretto	99,779	13,354	96,613	116,048	1,311,068
Ludington					1,001,518
Millie (Hewitt)	18,691	3,322	10,887		368,265
Munro	46,834	27,773	23,241	20,022	298,578
Norway					1,291,352
Penn Iron Mining Co	381,128	176,211	428,004	344,760	5,182,108
Perry					3,138
Pewabec	457,796	365,341	465,453	380,376	7,298,076
Quinnesec			3,147	744	503,647
Saginaw (Perkins)	26,080	38,669	19,994		501,985
Stephenson					39,350
Sturgeon River					19,404
Verona					130,975
Vivian	48,493	10,056		14,827	420,239
Vulcan					1,668,654
Walpole					19,089
Total	2,498,784	1,254,110	1,991,108	1,674,447	46,390,151
Metropolitan Trough.					
Groveland	13,913	9,123	24,933	26,462	100,554
Metropolitan					107,027
Northwestern					35,810
Total	13,913	9,123	24,933	26,462	243,391
Calumet Trough.					
Calumet	51,646	15,222			121,354

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.[1]

	1882.	1883.	1884.	1885.	1886.
Baker					
Baltic					
Berkshire					
Beta					1,585
Caspian					
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha					
Iron River	29,115	100,369	52,584	55,693	78,591
James (Osana)					
Dober					
Nanaimo	2,480	29,221	37,620		5,400
Riverton					
Selden					790
Sheridan					
Tully					
Youngs					
Zimmerman					
Total	31,595	129,590	90,204	55,693	86,366
	1887.	**1888.**	**1889.**	**1890.**	**1891.**
Baker					
Baltic					
Berkshire					
Beta	1,226				1,400
Caspian					
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha					
Iron River	83,018	110,000	179,238	155,458	59,345
James (Osana)					
Dober					
Nanaimo	30,460	5,744		3,441	13,200
Riverton					
Selden	1,302				
Sheridan			1,102	595	7,137
Tully					
Youngs					
Zimmerman					
Total	116,606	115,744	180,340	159,494	81,082

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1892.	1893.	1894.	1895.	1896.
Baker					
Baltic					
Berkshire					
Beta					
Caspian					
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha		1,683		1,201	
Iron River	1,176				
James (Osana)					
Dober					
Nanaimo					
Riverton					
Selden					
Sheridan	45,744	2,234		16,754	3,419
Tully					
Youngs					
Zimmerman					
Total	46,921	3,917		17,955	3,419

	1897.	1898.	1899.	1900.	1901.
Baker					
Baltic					17,326
Berkshire					
Beta					
Caspian					
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha				11,008	20,355
Iron River					
James (Osana)					
Dober		5,009	10,980	49,203	
Nanaimo					
Riverton			2,262	71,004	119,860
Selden					
Sheridan	146		31,104	8,063	
Tully					
Youngs					
Zimmerman					
Total	146	5,009	44,346	139,278	157,541

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1902.	1903.	1904.	1905.	1906.
Baker					
Baltic	64,664	123,236	151,114	133,246	186,495
Berkshire					
Beta					
Caspian		2,088	4,242	10,248	80,875
Chatham					
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty					
Hiawatha	74,596	53,828	38,288	9,704	20
Iron River					
James (Osana)					
Dober					
Nanaimo			9,086	91,238	91,792
Riverton	215,850	97,633	81,543	82,611	161,704
Selden					
Sheridan					
Tully					
Youngs				10,926	47,583
Zimmerman					
Total	355,110	276,785	284,273	337,973	568,469

	1907.	1908.	1909.	1910.	Total.
Baker			45,003	39,417	84,420
Baltic	189,119	129,037	174,426	171,930	1,340,593
Berkshire		3,440	34,295	97,999	135,734
Beta					4,211
Caspian	138,867	102,628	189,023	171,334	699,305
Chatham	14,883	45,826	68,730	51,988	181,427
Davidson No. 1					
Davidson No. 2					
Chicagon					
Fogarty	7,949	32,560	77,356	51,071	168,936
Hiawatha		138,190	136,739	128,884	614,496
Iron River					904,587
James (Osana)	2,360	59,760	90,851	78,388	231,359
Dober					65,192
Nanaimo	53,778	305			373,765
Riverton	90,358	47,073	171,200	84,269	1,225,367
Selden					2,092
Sheridan					116,299
Tully				2,726	2,726
Youngs	92,632	70,094	154,150	98,399	473,784
Zimmerman		1,832	10,303	25,555	37,690
Total	589,946	630,745	1,152,076	1,001,960	6,661,983

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.[1]

	1882.	1883.	1884.	1885.	1886.
Alpha					
Armenia					50,275
Bristol (Claire)					
Columbia	15,948	4,334	6,774		14,282
Crystal Falls	1,341				
Delphic		3,410	508	9,880	17,648
Dunn					
Fairbanks	8,045	455			
Genesee (Ethel)					
Gibson					
Great Western	587	22,825	20,710		22,267
Hemlock					
Hilltop					
Hollister					
Hope					
Kimball					
Lamont (Monitor)					
Lee Peck					
Lincoln					
Mangonate					
Mansfield					
Mastodon	3,477	18,577	18,187	11,737	41,640
McDonald					
Michigan					
Monongahela					
Paint River (Fairbanks)	6,515	5,973	11,652	2,373	13,933
Shelden & Shafer (Union) (see Columbia)					
South Mastodon					
Tobin					
Youngstown	6,198	15,292	8,344		25,635
Total	42,111	70,866	66,175	23,990	185,680

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1887.	1888.	1889.	1890.	1891.
Alpha					
Armenia	26,649				
Bristol (Claire)					
Columbia	2,377	10,936	11,385	60,133	70,770
Crystal Falls				3,974	
Delphic	2,272				
Dunn	24,677	118,096	151,826	156,963	162,721
Fairbanks					
Genesee (Ethel)					
Gibson					
Great Western	23,239	21,860	38,454	72,546	62,464
Hemlock					35,531
Hilltop					
Hollister				2,020	1,057
Hope					
Kimball					
Lamont (Monitor)			12,348	31,139	26,226
Lee Peck					
Lincoln					1,813
Mangonate				6,844	
Mansfield				18,303	49,836
Mastodon	48,792	51,463	63,511	66,526	45,370
McDonald					
Michigan					
Monongahela					
Paint River (Fairbanks)	10,240	12,506	32,700	62,654	45,435
Shelden & Shafer (Union) (see Columbia)					
South Mastodon		2,722	4,005	1,476	
Tobin					
Youngstown	34,418	12,699		44,460	3,705
Total	172,665	230,282	314,229	527,038	504,928

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1892.	1893.	1894.	1895.	1896.
Alpha					
Armenia				2,045	
Bristol (Claire)	57,352	9,612			
Columbia	57,682	22,426	10,300	70,867	87,202
Crystal Falls				13,037	44,526
Delphic					52
Dunn	133,666	58,590	24,538	90,885	47,081
Fairbanks					
Genesee (Ethel)					
Gibson	16,357				
Great Western	87,487	661			14,643
Hemlock	65,459	11,323		949	94,645
Hilltop					
Hollister	1,021				
Hope	15,543	2,275			
Kimball					
Lamont (Monitor)	42,819	13,777	2,600		
Lee Peck	2,844				
Lincoln	26,019	8,757			
Mangonate					
Mansfield	69,259	69,558			
Mastodon	9,150	23,485		23,733	60
McDonald					
Michigan		505	77	1,071	
Monongahela					
Paint River (Fairbanks)	18,390				
Shelden & Shafer (Union) (see Columbia)					
South Mastodon					
Tobin					
Youngstown				13	
Total	603,048	220,969	37,515	202,600	288,209

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1897.	1898.	1899.	1900.	1901.
Alpha					
Armenia					18,750
Bristol (Claire)			80,915	51,639	36,593
Columbia	24,623	14,199	126,290	97,531	19,963
Crystal Falls	95,210	128,233	147,346	197,770	230,614
Delphic					
Dunn	31,062	49,381	7,458		
Fairbanks					
Genesee (Ethel)					
Gibson					
Great Western		33,851	43,316	98,550	123,261
Hemlock	96,032	69,865	110,269	72,413	149,966
Hilltop			3,496	6,410	2,503
Hollister					
Hope					
Kimball					
Lamont (Monitor)			67,652	31,323	
Lee Peck					
Lincoln			43,622	72,959	19,727
Mangonate					
Mansfield	37,182	60,739	86,607	90,155	74,113
Mastodon					
McDonald					
Michigan	216				
Monongahela					2,397
Paint River (Fairbanks)				1,316	
Shelden & Shafer (Union) (see Columbia)					
South Mastodon					
Tobin					18,957
Youngstown	661				
Total	284,986	356,268	716,971	720,066	696,844

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1902.	1903.	1904.	1905.	1906.
Alpha	....	1,370	....	....	....
Armenia	100,864	31,901	16,577	....	27,882
Bristol (Claire)	129,035	246,581	132,420	210,388	298,031
Columbia	186,798	....	....	27,883	....
Crystal Falls	195,555	117,096	180,983	152,255	111,871
Delphic	....	....	....	....	....
Dunn	2,816	5,365	....	21,051	91,476
Fairbanks	....	....	....	....	....
Genesee (Ethel)	14,455	61,694	132,380	77,370	80,971
Gibson	....	....	....	....	....
Great Western	42,470	100,751	68,318	191,265	311,218
Hemlock	123,331	79,420	136,232	124,450	106,437
Hilltop	....	....	....	....	7,820
Hollister	....	....	....	....	....
Hope	3,373	7,339	....	....	....
Kimball	....	....	....	....	....
Lamont (Monitor)	47,267	43,736	29,393	74,991	89,980
Lee Peck	....	....	....	....	....
Lincoln	7,747	15,606	17,577	19,539	5,890
Mangonate	....	....	....	....	....
Mansfield	31,181	51,440	79,163	38,584	....
Mastodon	....	....	....	....	....
McDonald	....	....	....	....	....
Michigan	53,272	....		58,088	146
Monongahela	....	6,913	....	....	....
Paint River (Fairbanks)	10,383	9,863	11,257	11,973	28,321
Shelden & Shafer (Union) (see Columbia)	....	....	....	....	....
South Mastodon	....	....	....	....	....
Tobin	55,238	45,386	113,669	166,529	235,867
Youngstown	....	....	....	....	....
Total	1,003,785	824,461	917,969	1,174,366	1,395,910

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.[1]

	1907.	1908.	1909.	1910.	Total.
Alpha					1,370
Armenia	36,665			65,473	377,081
Bristol (Claire)	345,676	190,300	396,825	270,742	2,456,109
Columbia					942,703
Crystal Falls	114,158	296	986		1,735,251
Delphic					33,770
Dunn	141,992	8,829	193,396	136,144	1,658,015
Fairbanks					8,500
Genesee (Ethel)	38,984		65,585	66,185	537,624
Gibson		4,548	36,246	45,202	102,353
Great Western	234,492	124,246	112,747	80,709	1,952,937
Hemlock	117,181	83,834	112,481	115,407	1,705,225
Hilltop					20,229
Hollister	6,371	10,671	25,842	49,434	96,416
Hope					28,530
Kimball	16,224				16,224
Lamont (Monitor)	42,090			3,183	558,524
Lee Peck					2,844
Lincoln	714		1,657		241,627
Mangonate					6,844
Mansfield	183,532	44,633	118,713	114,357	1,217,355
Mastodon					425,708
McDonald			1,114	6,022	7,136
Michigan	39,819	603		17,922	171,719
Monongahela					9,310
Paint River (Fairbanks)	75,805				371,289
Shelden & Shafer (Union) (see Columbia)					
South Mastodon					8,203
Tobin	237,781	161,642	359,668	235,812	1,630,549
Youngstown					151,425
Total	1,631,484	629,602	1,425,261	1,206,592	16,474,870

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT.[1] (GROSS TONS)

	1872.	1873.	1874.	1875.
(Austin) (Princeton) (Swanzy or Chesire)..... Stegmiller (Stephenson)	13,445	9,328	....	187
Total........................	13,445	9,328	....	187
	1876	1877.	1878.	1879.
(Austin) (Princeton) (Swanzy or Chesire)..... Stegmiller (Stephenson)	225	8,444	16,924	17,985
Total........................	225	8,444	16,924	17,985
	1880.	1881.	1882.	1883.
(Austin) (Princeton) (Swanzy or Chesire)..... Stegmiller (Stephenson)	13,302	15,011	31,498	13,730
Total........................	13,302	15,011	31,498	13,730
	1884.	1885.	1886.	1887.
(Austin) (Princeton) (Swanzy or Chesire)..... Stegmiller (Stephenson)	3,557	....	8,328	2,142
Total........................	3,557	....	8,328	2,142
	1888.	1889.	1890.	1891.
(Austin) (Princeton) (Swanzy or Chesire)..... Stegmiller (Stephenson)	....	....	....	7,301
Total........................	....	....	....	7,301

[1] From Iron Trade Review.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

	1892.	1893.	1894.	1895.
(Austin) (Princeton) Swanzy or Chesire) Stegmiller (Stephenson)	29,403	19,096	....	6,593
Total	29,403	19,096	....	6,593

	1896.	1897.	1898.	1899.
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	....	....	25,247	55,802
Total	....	....	25,247	55,802

	1900.	1901.	1902.	1903.
(Austin) (Princeton) (Swanzy or Chesire) Stegmiller (Stephenson)	75,037	67,051	118,048	84,223
Total	75,037	67,051	118,048	84,223

	1904.	1905.	1906.	1907.
(Austin)	....	....	....	195,950
(Princeton) (Swanzy or Chesire)	76,461	129,079	166,894	177,863
Stegmiller				
(Stephenson)	....	....	....	6,305
Total	76,461	129,079	166,894	380,118

	1908.	1909.	1910.	Total.
(Austin)	111,229	125,858	188,588	621,625
(Princeton) (Swanzy or Chesire)	36,033	42,934	89,441	1,360,612
Stegmiller	....	39,869	48,842	88,711
(Stephenson)	52,588	64,075	225,726	348,694
Total	199,850	272,736	552,597	2,419,642

CARGO ANALYSES OF THE IRON ORES SHIPPED FROM THE IRON RIVER, CRYSTAL FALLS AND MENOMINEE DISTRICTS IN 1910.[1]

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Antoine	Clifford	Dried	39.25	.017	41.29	.18	.92	.57	.72	.016	1.00	
		Natural	38.36	.017	40.35							2.28
	Antoine	Dried	38.62	.030	42.13	.15	.95	.59	.75	.017	1.05	
		Natural	37.87	.029	41.31							1.95
Aragon	Granada	Dried	59.79	.061	7.12	.16						
		Natural	55.16	.057	6.57							7.74
	Briar Hill	Dried	54.64	.054	8.09	.29						
		Natural	51.81	.051	7.67							5.18
	Cadiz	Dried	51.16	.054	17.03	.17						
		Natural	47.44	.051	15.80							7.26
Armenia		Dried	57.32	.310	8.86	.54	2.66	1.37	.80	.005	3.20	
		Natural	51.24	.271	7.92							10.60
Baker		Dried	56.64	.348	7.67	.51	1.60	1.93	1.20	.008	4.70	
		Natural	51.68	.318	6.99							8.75
Baltic		Dried	55.60	.456	7.96	.32	3.11	1.57	1.49	.048	4.94	
		Natural	50.32	.413	7.20							9.50
Berkshire		Dried	54.25	.720	10.25	.22	4.52	2.60	2.43	.046	3.05	
		Natural	46.97	.645	9.18							10.44
Breen		Dried	39.00	.016	41.53	.03	.89	.35	.80	.027	.60	
		Natural	37.83	.016	40.28							3.00
Bristol	Bristol	Dried	54.86	.633	6.45	.74	2.83	2.77	1.54	.111	5.26	
		Natural	50.58	.584	5.95							7.80
	Manganate	Dried	50.36	.593	6.90	3.21	3.60	2.17	2.41	.055	7.72	
		Natural	46.52	.548	6.37							7.63
Buckeye (Wis.)		Dried	52.40	.436	10.75	.13	2.75	2.22	2.51	.196	6.50	
		Natural	48.21	.401	9.89							8.00
Calumet		Dried	41.75	.023	34.67	.20	2.23	.72	.96	.009	1.46	
		Natural	39.87	.022	33.11							4.50
Caspian		Dried	55.60	.456	7.96	.32	3.11	1.57	1.49	.048	4.94	
		Natural	50.32	.413	7.20							9.50
Chapin	Chapin	Dried	57.97	.065	6.44	.35						
		Natural	53.82	.060	5.98	.32						7.16
	Ajax	Dried	51.73	.055	14.70	.33						
		Natural	48.20	.052	13.69	.31						6.83
Chatham		Dried	53.94	.328	11.12	.18	2.00	.82	.98	1.39	6.47	
		Natural	50.84	.309	10.48							5.74
*Crystal Falls		Dried	56.70	.616	7.60	.69	1.73	2.35	1.90	.006	3.40	
		Natural	51.78	.562	6.94							8.68
Cyclops and Norway, West Vulcan, Curry and Brier Hill	Cyclops	Dried	60.35	.015	9.77	.07	2.16	.81	1.26	.048		
		Natural	56.11	.014	9.05							7.37
	Vulcan	Dried	53.38	.055	11.72	.01	2.30	.76	1.57	.054		
		Natural	54.68	.051	10.83							7.58
	Jupiter	Dried	41.81	.017	33.32		2.95	.69	.88	.050		
		Natural	39.52	.016	31.35							5.92
	Harper	Dried	59.95	.100	7.33	.11	1.38	1.13	2.27	.033	2.05	
		Natural	56.53	.094	6.91							5.70

Davidson No. 1*		Dried	56.90	.595	2.88	.35	2.78	.45	.40	.056	10.90	
		Natural	52.63	.550	2.66							7.50
Dunn		Dried	57.10	.590	6.47	.70	1.91	2.58	2.10	.007	3.05	
		Natural	52.45	.542	5.94							8.15
Florence		Dried	54.80	.269	6.43	.18	3.91	2.14	3.01	1.85	4.77	
		Natural	49.31	.242	5.79							10.02
Fogarty		Dried	55.60	.456	7.96	.32	3.11	1.57	1.49	.048	4.94	
		Natural	50.32	.413	7.20							9.50
Genesee		Dried	57.08	.587	7.33	.35	2.12	2.63	2.55	.008	2.88	
		Natural	52.14	.536	6.70							8.65
Great Western	Great Western	Dried	55.00	.517	6.89	.74	2.90	2.98	2.12	.043	3.16	
		Natural	50.41	.474	6.31							8.35
	Basic	Dried	50.50	.420	6.12	.42	4.80	2.57	3.64	2.93	.091	
		Natural	46.28	.385	5.61							8.35
Groveland		Dried	46.35	.039	19.54	1.04	2.06	2.81	3.86	.011	3.86	
		Natural	45.16	.038	19.04							2.56
Hemlock		Dried	52.50	.196	4.42	.40	2.53	5.64	3.68	.016	7.69	
		Natural	51.03	.191	4.30							2.80
James (Osana)		Dried	55.50	.488	8.73	.22	1.13	.46	.22	.017	8.72	
		Natural	51.06	.449	8.03							8.00
Hollister		Dried	54.50	1.021	11.00	1.12	1.53	4.36	.38	.39	1.02	
		Natural	51.23	.960	10.34							6.00
Loretto	Russell	Dried	53.04	.053	10.25	.27	2.82	2.10	3.85	.006	4.42	
		Natural	49.12	.049	9.49							7.40
	Russell Special	Dried	47.40	.059	18.02	.16	2.63	1.35	2.33	.005	3.81	
		Natural	43.89	.055	16.69							7.40
Mansfield		Dried	57.19	.119	5.30	.18						
		Natural	51.63	.108	4.78							9.72
McDonald		Dried	57.00	.100	6.00	.30	2.50					
		Natural										
Michigan		Dried	55.72	.193	10.54	.21						
		Natural	50.71	.175	9.59							9.00
Millie*	Algoma	Dried	58.60	.045	8.30	.17	1.09	2.15	1.98	.041	2.40	
		Natural	56.10	.043	7.95							4.26
	Dory	Dried	40.55	.027	36.25	.15	.82	.98	1.07	.012	2.10	
		Natural	39.94	.027	35.71							1.50
Pewabic	Pewabic	•Dried	59.80	.012	10.38	.12	1.04	.74	1.12	.006	1.31	
		Natural										
	Toledo	Dried	48.10	.014	25.78	.09	1.40	.89	1.35	.015	1.79	
		Natural										
	Pewabic Genoa	Dried	38.85	.012	39.34	.07	1.49	.58	1.48	.009	1.48	
		Natural										
	Walpole	Dried	57.30	.074	7.01	.18	1.66	1.99	3.16	.005	3.93	
		Natural	53.11	.0686	6.498							7.31
	Tyrone	Dried	56.65	.030	11.56	.10	.83	1.66	1.75	.007	3.08	
		Natural										

[1] Published by Lake Superior Iron Ore Association.
* Expected Analysis for 1911.

CARGO ANALYSES OF THE IRON ORES SHIPPED FROM THE IRON RIVER, CRYSTAL FALLS AND MENOMINEE DISTRICTS IN 1910

(Concluded.)

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Quinnesec		Dried	40.70	.032	37.40	.07	1.05	1.45	.77	.006	.95	
		Natural	39.40	.031	36.20							3.20
Riverton (Dober)		Dried	56.20	.611	6.12	.21						
		Natural	51.91	.564	5.65							7.64
Tobin		Dried	57.05	.595	6.82	.32	1.69	2.90	2.68	.007	2.83	
		Natural	52.33	.546	6.25							8.28
Tully		Dried	56.72	.516	7.95	.42	1.73	2.09	1.56	.007	4.32	
		Natural	51.67	.470	7.24							8.91
Vivian		Dried	37.60	.016	40.82	.05	1.18	1.15	1.29	.009	1.72	
		Natural	36.47	.016	39.60							3.00
Youngs		Dried	55.40	.336	9.92	.14	3.17	.75	1.01	.068	4.90	
		Natural	51.20	.311	9.17							7.58

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE FOR 1910.[1]

Mine	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Ashland	Ashland	Dried	58.00	.048	10.35	.28	3.03	.27	.22	.010	2.78	
		Natural	51.85	.043	9.25							10.60
	Globe	Dried	57.85	.103	11.00	.28	2.87	.53	.47	.017	2.20	
		Natural	52.06	.093	9.90							10.00
Atlantic (Wis.)		Dried	59.85	.035	10.15	.33						
		Natural	53.11	.031	9.01							11.25
Cary (Wis.)	Brotherton	Dried	62.20	.027	8.59	.42	.82	.24	.26	.006	.64	
		Natural	56.91	.025	7.86							8.50
	Brotherton No. 2	Dried	61.00	.045	10.30	.42	.82	.24	.26	.006	.64	
		Natural	55.82	.041	9.42							8.50
	Walton	Dried	61.00	.085	10.30	.42	.82	.24	.26	.006	.64	
		Natural	55.82	.078	9.43							8.50
	Cary Empire	Dried	53.20	.056	12.22	4.14	.93	.19	.16	.010	4.62	
		Natural	48.41	.051	11.12							9.00
	Cary Bessemer & Windsor	Dried	57.05	.046	12.80	.82	.96	.17	.19	.010	3.18	
	Kakagon	Dried	55.80	.076	9.67	3.00	1.01	.37	.34	.007	4.54	
	Nimikon	Dried	58.00	.066	11.72	.36	1.15	.42	.33	.013	2.88	
Castile	Castile	Dried	58.02	.045	13.98	.56	.44	.47	.45	.015	1.00	
		Natural	50.76	.039	12.23							12.52
	Medina	Dried	57.35	.125	13.01	.60	.60	.54	.39	.013	1.25	
		Natural	50.10	.109	11.36							12.65
Colby	Colby	Dried	60.05	.049	7.19	.32	1.53	.93	.82	.005	2.96	
		Natural	53.80	.044	6.44							10.40
	Colby No. 2	Dried	59.65	.060	7.53	.38	1.40	1.05	.91	.007	3.09	
		Natural	53.22	.054	6.72							10.78
Eureka	Belmont	Dried	61.50	.055	6.65	.70	1.28	.40	.62	.022	2.10	
		Natural	52.08	.047	5.63							15.31
	Eureka	Dried	62.59	.065	5.76	.83	1.37	.13	.34	.012	1.96	
		Natural	52.81	.055	4.86							15.63
	Ramsay	Dried	61.48	.094	6.72	.63	1.70	.67	.39	.017	1.90	
		Natural	52.10	.080	5.70							15.25
Germania (Wis.)		Dried	55.50	.064	14.85	.27	1.19	.68	.55	.011	2.55	
		Natural	49.59	.057	13.27							10.65
Ironton	Ironton	Dried	60.02	.048	6.98	.36	1.66	.81	.54	.006	3.12	
		Natural	53.69	.043	6.24							10.55
	Ironton No. 2	Dried	59.68	.061	7.85	.35	1.82	.98	.76	.008	2.81	
		Natural	53.20	.054	6.99							10.86
Montreal	Montreal	Dried	63.64	.045	4.20	.38	.92	trace	trace	.004	3.82	
		Natural	57.40	.041	3.79							9.80
	Lawrence	Dried	61.24	.055	6.52	.48	1.67	.35	.16	.010	4.00	
		Natural	54.69	.049	5.82							10.70
Mikado		Dried	58.10	.109	11.03	.90	.87	.73	.37	.008	2.46	
		Natural	49.68	.093	9.43							14.50

[1] Published by the Lake Superior Iron Ore Association.

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE FOR 1910.[1]

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Newport	Melrose	Dried	61.60	.045	5.98	.34	2.70	.67	.17	.014	2.12	
		Natural	54.45	.040	5.29							11.61
	New Erie No. 1	Dried	56.55	.047	12.61	.32	2.97	.63	.14	.020	1.93	
		Natural	49.77	.041	11.10							11.99
	Montrose	Dried	60.95	.078	6.60	.41	1.63	.35	.56	.033	3.13	
		Natural	54.29	.069	5.88							10.92
	New Era No. 2	Dried	55.95	.080	12.63	.34	3.18	.60	.26	.015	2.67	
		Natural	50.06	.072	11.30							10.52
	Bonnie	Dried	48.35	.047	14.58	6.95	1.02	.20	.95	.023	4.00	
		Natural	44.65	.043	13.46							7.66
Norrie-Aurora	Aurora	Dried	61.48	.035	6.25	.36						
		Natural	54.48	.031	5.54							11.39
	Norrie	Dried	61.63	.034	5.98	.36						
		Natural	54.82	.030	5.32							11.06
	Nordale	Dried	56.26	.044	11.65	.33						
		Natural	50.04	.039	10.36							11.06
	Vaughn	Dried	61.35	.033	6.24	.36						
		Natural	54.11	.029	5.51							11.81
	Norden	Dried	61.57	.088	6.90	.37						
		Natural	54.41	.077	6.10							11.63
Ottawa (Odanoh) (Wis.)	Ottawa	Dried	55.99	.052	8.82	3.37	1.01	.27	.25	.011	5.06	
		Natural	51.10	.047	8.05							8.74
	Ottawa Manganese	Dried	53.79	.055	8.75	5.69	1.06	.18	.32	.009	5.66	
		Natural	49.22	.050	8.01	5.21						8.50
	Ontario	Dried	56.30	.068	9.67	2.36	1.17	.24	.19	.008	5.18	
		Natural	51.63	.062	8.87							8.30
Puritan		Dried	62.76	.048	5.03	.62						
		Natural	54.59	.042	4.37							13.02
Sunday Lake	Sunday Lake	Dried	59.70	.025	12.25	.45	.86	.21	.19	.007	.54	
		Natural	54.33	.023	11.15							9.00
	Earl	Dried	59.00	.085	12.70	.48	.84	.38	.27	.009	.70	
		Natural	54.87	.079	11.81							7.00
Tilden	Tilden	Dried	63.10	.044	3.96	.70						
		Natural	56.36	.039	3.54							10.68
	Rand	Dried	56.79	.042	9.27	1.77						
		Natural	48.84	.036	7.98							14.00
	Norden	Dried	62.37	.120	4.25	.55						
		Natural	54.27	.104	3.70							12.98
	Norden No. 2	Dried	58.23	.094	10.03	.63						
		Natural	51.28	.083	8.84							11.93

[1] Published by the Lake Superior Iron Ore Association.

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE FOR 1910.[1]

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
American	American	Dried	57.60	.040	12.34	.04	3.44	.31	.36	.011	1.10	
		Natural	56.42	.039	12.09							2.05
	Alliance	Dried	53.18	.039	17.54	.03	4.14	.25	.48	.022	1.07	
		Natural	52.27	.038	17.24							1.71
Angeline	Angeline Hematite	Dried	65.30	.041	3.79							
		Natural	59.21	.037	3.43							9.32
	South Angeline Hematite	Dried	63.95	.128	4.40							
		Natural	57.50	.115	3.95							10.08
Breitung Hematite No. 1	Foley	Dried	63.27	.017	6.43	.08	1.45	.18	.18	.010	1.50	
		Natural	58.37	.016	5.93							7.74
	Foley No. 2	Dried	54.88	.018	17.85	.08	1.70	.22	.11	.010	1.50	
		Natural	50.45	.017	16.41							8.06
	Breitung Siliceous	Dried	43.20	.018	33.94	.21	1.93	1.21	Trace	.027	.79	
		Natural	40.41	.017	31.75							6.46
	Hematite Siliceous	Dried	43.00	.033	34.00	.84	2.24	1.68	.12	.008	1.58	
		Natural	40.42	.031	31.96							6.00
Breitung Hematite No. 2	Mary	Dried	58.73	.103	8.35	.23	2.98	.62	.63	.026	2.59	
		Natural	50.82	.089	7.23							
	Charlotte	Dried	54.35	.090	14.60	.45	2.85	.81	1.40	.022	1.96	
		Natural	48.07	.080	12.91							11.56
Cambria		Dried	57.90	.093	9.82	.24	2.64	.76	.48	.013	3.17	
		Natural	51.54	.083	8.74							10.98
Champion		Dried	61.90	.078	5.15							
		Natural	61.35	.077	5.11							.88
Cliff Shaft	Crushed Cliff Shaft	Dried	59.20	.112	6.42	.51	2.74	1.87	.82	.014	1.92	
		Natural	58.61	.111	6.37							1.00
	Lump Cliff Shaft	Dried	59.70	.103	4.90	.79	2.46	1.75	1.12	.016	2.75	
		Natural	59.40	.102	4.88							.50
Empire		Dried	40.23	.074	40.60	.08	1.02	.49	.24	.025	1.10	
		Natural	39.01	.072	39.37							3.03
Hartford	Bernhart	Dried	59.14	.074	11.98							
		Natural	50.53	.066	10.78							10.00
	Averhart	Dried	59.52	.059	8.04							
		Natural	53.52	.053	7.23							10.07
*Himrod		Dried	41.75	.054	36.20	.03	1.28	.38	.05	.005	1.50	
		Natural	40.08	.052	34.75							4.00
*Imperial		Dried	51.40	.032	11.15	.180	.64	2.98	2.12	.021	8.63	
		Natural	45.39	.267	9.85							11.70
	Jackson Bessemer	Dried	50.30	.042	24.50	.10	2.00	.35	.08	.015	1.00	
		Natural	49.29	.041	24.01							2.01

[1] Published by the Lake Superior Iron Ore Association.

* Expected analysis for 1911.

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AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE FOR 1910.[1] (Concluded.)

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Lake Superior (Hard)	South Jackson	Dried	41.70	.086	31.50	2.60	1.51	.34	.27	.022	2.48	
		Natural	38.68	.080	29.22							7.25
	Lake	Dried	58.70	.108	6.68	.70	2.68	.65	.98	.015	3.75	
		Natural	51.07	.094	5.81							13.00
	Lake Bessemer	Dried	60.00	.048	9.73	.54	1.27	.66	.30	.011	1.45	
		Natural	51.02	.042	8.44							13.30
	Abbotsford	Dried	62.13	.033	6.30							
		Natural	59.78	.032	7.98							3.78
	Beresford Lump	Dried	62.58	.110	5.40							
		Natural	61.59	.108	5.32							1.59
	Castleguard	Dried	53.01	.045	20.87							
		Natural	50.63	.043	19.94							4.48
	Castleford	Dried	53.97	.086	16.51							
		Natural	51.91	.082	15.88							3.81
	High Grade Hematite	Dried	60.40	.082	8.39							
		Natural	52.08	.070	7.23							13.78
Lake Superior (Soft)	Alford	Dried	62.89	.028	6.69							
		Natural	56.68	.025	6.03							9.87
	Bedford	Dried	55.11	.073	13.63							
		Natural	49.61	.066	12.27							9.98
Lillie		Dried	58.21	.090	9.20	.26	2.56	.78	.40	.016	3.47	
		Natural	51.23	.079	8.10							11.99
Maas		Dried	58.80	.089	8.50	.25	2.56	1.23	.27	.018	2.60	
		Natural	52.04	.079	7.52							11.50
Mary Charlotte No. 1	Mary	Dried	58.73	.013	8.35	.23	2.98	.62	.63	.026	2.59	
		Natural	50.82	.089	7.23							13.47
	Charlotte	Dried	54.35	.090	14.60	.45	2.85	.81	1.40	.022	1.96	
		Natural	48.07	.079	12.91							11.56
Mary Charlotte No. 2	Mary	Dried	58.73	.103	8.35	.23	2.98	.62	.63	.026	2.59	
		Natural	50.82	.089	7.23							13.47
	Charlotte	Dried	54.35	.090	14.60	.45	2.85	.81	1.40	.022	1.96	
		Natural	48.07	.079	12.91							11.56
*Milwaukee-Davis	Milwaukee	Dried	62.05	.105	4.32	.45	.60	1.10	.90	.08	2.10	
		Natural	55.85	.095	3.89							10.00
	Davis	Dried	61.40	.127	5.25	.45	1.19	1.10	.72	.02	2.08	
		Natural	55.26	.114	4.73							10.00
Moro		Dried	60.30	.140	8.40	.12	2.72	.58	.12	.020	.30	
		Natural	60.00	.139	8.36							.50
Negaunee	Negaunee	Dried	58.80	.089	8.50	.25	2.56	1.23	.27	.018	2.60	
		Natural	52.04	.079	7.52							11.50
	Negaunee Bessemer	Dried	59.80	.060	7.65	.24	2.69	1.12	.23	.013	2.20	
		Natural	53.22	.053	6.81							11.00

*Ogden		Dried	41.70	.045	37.10	.37	.69	.30	.13	.010	1.20	
		Natural	41.14	.044	36.60							1.34
Queen	Buffalo	Dried	60.12	.112	6.18							
		Natural	51.40	.096	5.30							14.36
	Cameo	Dried	57.24	.104	8.77							
		Natural	48.99	.089	7.51							14.41
Republic	Republic	Dried	62.82	.049	7.93	.04	1.44	.56	.61	.028	.28	
		Natural	62.20	.049	7.85							.96
	Basic	Dried	63.65	.077	5.54	.06	1.50	.56	.90	.027	.14	
		Natural	62.80	.076	5.47							1.33
	Lump	Dried	66.40	.094	2.36	.06	.95	.52	.72	.012	none	
		Natural	65.86	.093	2.34							.82
Richmond		Dried	40.90	.040	38.10	.12	.81	.35	.80	.014	1.31	
		Natural	39.66	.039	36.95							3.03
Rolling Mill		Dried	59.76	.102	8.25							
		Natural	51.60	.088	7.12							13.65
Salisbury	Clinton	Dried	60.50	.220	6.75	.30	2.30	.70	.23	.014	2.57	
		Natural	53.24	.194	5.94							12.00
	Clinton Silica	Dried	51.50	.106	19.35	.26	2.46	.30	.16	.012	2.68	
		Natural	45.06	.093	16.93							12.50
	Salisbury	Dried	59.10	.110	7.00	.60	3.00	1.20	1.20	.040	2.50	
		Natural	50.83	.095	6.02							14.00
*Star West		Dried	54.16	.037	18.42	.21	.76	1.10	.85	.002	1.12	
		Natural	53.21	.036	18.09							1.76
Washington	Washington	Dried	60.20	.137	10.43	.06	1.52	.93	.84	.021	.34	
		Natural	59.61	.136	10.33							.98
	Washington No. 2	Dried	57.12	.123	14.03	.33	1.68	.66	.62	.016	1.60	
		Natural	56.68	.122	13.92							.77
	Washington Siliceous	Dried	50.00	.100	25.00	.44	.84	.88	.10	.031	.42	
		Natural	49.50	.099	24.75							1.00

[1] Published by the Lake Superior Iron Ore Association.
* Expected analysis for 1911.

AVERAGE CARGO ANALYSES OF IRON ORE SHIPMENTS FROM THE GWINN DISTRICT FOR 1910.

Mine.	Ore.		Iron.	Phos.	Silica.	Mang.	Alum.	Lime.	Magnes.	Sulph.	Loss.	Moist.
Austin		Dried	60.80	.086	8.95	.52	.71	.88	.28	.012	.95	
		Natural	52.29	.074	7.70							14.00
Princeton	Princeton	Dried	59.70	.197	8.80	.48	.95	1.60	.62	.013	1.20	
		Natural	51.34	.169	7.56							14.00
	Cambridge	Dried	60.00	.667	6.12	.74	1.07	2.15	.42	.014	1.25	
		Natural	51.60	.574	5.26							14.00
Stegmiller		Dried	60.34	.381	6.97							
		Natural	51.44	.325	5.95							14.74
Stephenson		Dried	60.00	.667	6.12	.74	1.07	2.15	.42	.014	1.25	
		Natural	51.60	.574	5.26							14.00

ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN IRON ORES, 1855-1911.[1]

Year.	Marquette Range.									
	Rail freight.		Boat freight.		Price at Lake Erie ports.		Value of ore at the mines.			
							Shipped via Marquette.		Shipped via Escanaba.	
	To Marquette.	To Escanaba.	From Marquette.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1855	$3 00	......	$3 00	......	$10 00	$10 00	$4 00	$4 00	......	......
1856	1 27	......	3 00	......	8 00	8 00	3 73	3 73	......	......
1857	1 27	......	2 67	......	8 00	8 00	4 06	4 06	......	......
1858	87	......	2 09	......	6 50	6 50	3 54	3 54	......	......
1859	87	......	2 00	......	6 00	6 00	3 13	3 13	......	......
1860	1 09	......	2 00	......	5 25	5 50	2 16	2 41	......	......
1861	1 09	......	2 21	......	5 25	5 00	1 95	1 70	......	......
1862	1 09	......	2 89	......	5 25	5 37	1 27	1 39	......	......
1863	1 09	......	3 19	......	7 50	7 50	3 22	3 22	......	......
1864	1 09	......	3 37	......	8 50	8 50	4 04	4 04	......	......
1865	1 10	......	3 23	......	7 50	7 50	3 17	3 17	......	......
1866	1 10	$1 55	4 17	$3 77	{ 9 50 { 14 00	...... 4 23	4 23 8 73	...... 4 18	$4 23 8 68	....
1867	1 10	1 80	2 98	3 28	10 50	{ 8 00 { 11 50	...... 6 42	3 92 7 42	...... 5 42	$2 92 6 42
1868	1 10	1 80	3 11	2 44	8 25	8 25	4 04	4 04	4 20	4 20
1869	1 10	1 85	3 21	2 43	8 25	9 50	3 94	5 19	3 97	5 22
1870	1 10	1 85	3 06	2 40	8 50	{ 8 50 { 9 50	...... 4 34	4 34 5 34	...... 4 25	4 25 5 25
1871	95	1 70	2 83	2 07	8 00	8 00	4 22	4 22	4 23	4 23
1872	84	1 70	3 59	2 50	9 00	7 50	4 57	3 07	4 80	3 30
1873	84	2 00	3 44	2 74	12 00	9 00	7 72	4 72	7 26	4 26
1874	84	2 00	3 84	......	9 00	7 00	4 32	2 32	......	......
1875	65	1 25	2 87	......	7 00	5 50	3 48	1 98	......	......
1876	55	1 15	2 54	......	6 75	4 50	3 66	1 41	......	......
1877	55	1 15	1 40	......	6 50	4 25	4 55	2 30	......	......
1878	55	1 15	1 26	85	5 50	4 25	3 69	2 44	3 50	2 25
1879	55	1 15	1 61	1 07	6 25	4 75	4 09	2 59	4 03	2 53
1880	55	1 25	2 50	1 77	9 25	8 00	6 20	4 95	6 23	4 98
1881	55	1 25	2 25	1 55	9 00	7 00	6 20	4 20	6 20	4 20
1882	55	1 25	1 50	1 22	9 00	6 25	6 95	4 20	6 53	3 78
1883	55	1 10	1 30	1 11	6 25	5 00	4 40	3 15	4 04	2 79
1884	40	80	1 21	98	5 76	4 50	4 15	2 89	3 98	2 72
1885	45	80	1 01	84	5 50	4 25	4 04	2 79	3 86	2 61
1886	55	80	1 35	1 16	5 50	4 75	3 60	2 85	3 54	2 79
1887	55	80	1 75	1 49	7 25	5 25	4 95	2 95	4 96	2 96
1888	45	70	1 22	97	5 50	4 75	3 83	3 08	3 83	3 08
1889	45	70	1 14	1 00	5 50	4 50	3 91	2 91	3 80	2 80
1890	45	70	1 16	99	6 75	5 75	5 14	4 14	5 06	4 06
1891	45	70	96	74	6 00	4 74	4 59	3 34	4 56	3 31
1892	40	65	1 06	87	5 50	4 85	4 04	3 39	3 98	3 33
1893	40	65	85	70	4 25	{ 3 00 { 3 50	...... 3 00	1 75 2 25	...... 2 90	1 65 2 15
1894	32	......	70	53	2 75	2 15	1 73	1 13	......	......

[1] Compiled from various sources.

ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN IRON ORES, 1855-1911.[1]

(Concluded.)

Year.	Marquette Range.									
	Rail freight.		Boat freight.		Price at Lake Erie ports.		Value of ore at the mines.			
							Shipped via Marquette.		Shipped via Escanaba.	
	To Marquette.	To Escanaba.	From Marquette.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1895	$0 32	$0 52	$0 83	$0 64	$2 75 3 50	$2 15 2 30	$1 60 2 35	$1 00 1 15	$1 59 2 34	$0 99 1 14
1896	32	52	80	61	4 00	2 45 2 85	...... 2 88	1 33 1 73	...... 2 78	1 32 1 72
1897	32	52	60	45	2 65	2 00 2 60	...... 1 73	1 08 1 68	...... 1 68	1 03 1 63
1898	32	40	60	48	3 10 3 35	2 35 2 45	2 18 2 43	1 43 1 53	2 22 2 47	1 47 1 57
1899	25	40	84	72	3 21 3 50	2 50	2 12 2 41	...... 1 41	2 09 2 38	...... 1 38
1900	25	40	94	85	5 93 6 48	.... 5 00	4 74 5 29	...... 3 81	4 68 5 23	...... 3 75
1901	25	40	74	62	4 66 4 92	3 65 3 85	3 67 3 93	2 66 2 86	3 64 3 90	2 63 2 83
1902	25	40	68	59	4 65 5 00	3 80 4 00	3 72 4 07	2 87 3 07	3 66 4 01	2 81 3 01
1903	25	40	73	63	4 85 5 15	4 00 4 25	3 87 4 17	3 02 3 27	3 82 4 12	2 97 3 22
1904	25	40	61	54	3 60 3 85	3 10 3 35	2 74 2 99	2 24 2 49	2 66 2 91	2 16 2 41
1905	32	40	70	60	3 75	3 20	2 73	2 18	2 75	2 20
1906	32	40	70	60	4 25	3 70	3 23	2 68	3 25	2 70
1907	32	40	70	60	5 00	4 20	3 98	3 18	4 00	3 20
1908	32	40	60	50	4 50	3 70	3 58	2 78	3 60	2 80
1909	32	40	60	50	4 50	3 70	3 58	2 78	3 60	2 80
1910	32	40	65	55	5 00	4 20	4 03	3 23	4 05	3 25
1911	......	......	55	45	4 50	3 70	......	......	......	......

[1] Compiled from various sources.

ANNUAL LAKE ERIE PRICES, FREIGHT RATES AND MINE VALUES OF MICHIGAN IRON ORES, 1855-1911.[1]

(Concluded.)

Year.	Menominee Range.						Gogebic Range.					
	Rail freight.	Boat freight.	Price of ore at Lake Erie ports.		Value of ore at the mines.		Rail freight.	Boat freight.	Price of ore at Lake Erie ports.		Value of ore at the mines.	
	To Escanaba.	From Escanaba.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.	To Ashland.	From Ashland.	Bessemer.	Non-Bessemer.	Bessemer.	Non-Bessemer.
1883	......	......	$6 00	$4 75	......	......	......	......	......	......	......	......
1884	......	......	5 25	4 50	......	......	......	......	......	......	......	......
1885	......	......	4 75	4 00	......	......	......	......	......	......	......	......
1886	......	......	5 25	4 50	......	......	......	......	......	......	......	......
1887	$0 85	$1 49	6 00	5 00	$3 66	$2 66	$0 80	$2 11	$6 00	$5 00	$3 09	$2 09
1888	75	97	4 75	4 00	3 03	2 28	70	1 34	4 75	4 00	2 71	1 96
1889	75	1 00	4 50	4 50	2 75	2 75	70	1 29	4 50	4 50	2 51	2 51
1890	......	99	5 50	5 25	4 51	4 26	70	1 26	5 50	5 25	3 54	3 29
1891	70	74	4 50	4 25	3 06	2 81	65	1 05	4 50	4 25	2 80	2 55
1892	70	87	4 50	3 65	2 93	2 08	65	1 20	4 50	3 65	2 65	1 80
1893	70	70	3 85	3 20	2 41	1 76	65	88	3 85	3 20	2 32	1 67
1894	70	53	2 75	2 50	1 52	1 27	52 65	 79	...... 2 75	...... 2 50	1 44 1 31	1 19 1 06
1895	52	64	2 90	2 25	1 74	1 09	52	96	2 90	2 25	1 42	77
1896	52	61	4 00	2 70	2 87	1 57	52	91	4 00	2 70	2 57	1 27
1897	52	45	2 60	2 15	1 63	1 18	45 52	 63	...... 2 60	...... 2 15	1 52 1 07	1 45 1 00
1898	45	48	2 75	1 85	1 82	92	40 45	 61	...... 2 75	...... 1 85	84 1 74	1 69 79
1899	40	72	3 00	2 15	1 88	1 03	40	95	3 00	2 15	1 65	80
1900	40	85	5 50	4 25	4 25	3 00	40	1 05	5 50	4 25	4 05	2 80
1901	40	62	4 25	3 00	3 23	1 98	40	84	4 25	3 00	3 01	1 76
1902	40	59	4 25	3 25	3 30	2 26	40	76	4 25	3 25	3 09	2 09
1903	40	63	4 50	3 60	3 47	2 57	40	83	4 50	3 60	3 27	2 37
1904	40	54	3 25	2 75	2 31	1 81	40	70	3 25	2 75	2 15	1 65
1905	40	60	3 75	3 20	2 75	2 20	40	76	3 75	3 20	2 59	2 04
1906	40	60	4 25	3 70	3 25	2 70	40	75	4 25	3 70	3 10	2 55
1907	40	60	5 00	4 20	4 00	3 20	40	75	5 00	4 20	3 85	3 05
1908	40	50	5 00	4 20	4 10	3 30	40	65	5 00	4 20	3 95	3 15
1909	40	50	4 50	3 70	3 60	2 80	40	65	4 50	3 70	3 45	2 65
1910	40	55	5 00	4 20	4 05	3 25	40	70	5 00	4 20	3 90	3 10
1911	......	45	4 50	3 70	......	......	......	60	4 50	3 70	......	......

[1]Compiled from various sources.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN.

Name of mine.	Location.				First shipment.	No. of men employed.
	County.	Section.	Twp.	Range.		
MARQUETTE RANGE:						
American	Marquette	32	48	28	1880	312
Angeline	Marquette	15	47	27	1864	411
Bessie	Marquette	35	46	29	1891	......
Breitung Hematite No. 1	Marquette	8	47	26	1903	......
Breitung Hematite No. 2	Marquette	8	47	26	......	......
Cambria	Marquette	35	48	27	1875	131
Champion	Marquette	31, 32	48	29	1867	103
Cliff Shaft	Marquette	9, 10	47	27	1887	290
Empire	Marquette	19	47	26	1907	......
Hartford	Marquette	36	48	27	1889	......
Imperial	Baraga	25	48	31	1890	80
Jackson	Marquette	1	47	27	1846	48
Lake	Marquette	10	47	27	1892	545
Lake Superior (Hard Ore)	Marquette	9, 10	47	27	1858	385
Lake Superior (Soft Ore)	Marquette	10	47	27	1858	385
Lillie	Marquette	35	48	27	1875	55
Lucy	Marquette	6, 7	47	26	1878	18
Mass	Marquette	31	48	26	1907	174
Maitland	Marquette	30	47	26	......	......
Mary Charlotte No. 1	Marquette	8	47	26	1903	} 453
Mary Charlotte No. 2	Marquette	8	47	26	......	
Milwaukee-Davis	Marquette	7	47	26	1879	......
Moro	Marquette	10	47	27	1881	......
Negaunee	Marquette	5, 6	47	26	1887	346
Ogden	Marquette	13	47	27	1892	......
Queen	Marquette	5	47	26	1888	336
Republic	Marquette	7	46	29	1872	437
Richmond	Marquette	28	47	26	1896	82
Rolling Mill	Marquette	City of Negaunee		......	1872	120
Salisbury	Marquette	15	47	27	1872	167
Volunteer	Marquette	30	47	26	1871	51
Washington	Marquette	11	47	29	1865	146
SWANZY DISTRICT:						
Austin	Marquette	20	45	25	1907	201
Princeton	Marquette	18, 20	45	25	1872	191
Stegmiller	Marquette	17	45	25	1909	44
Stephenson	Marquette	20	45	25	1907	40
MENOMINEE RANGE:						
Antoine	Dickinson	17, 20	40	30	1895	......
Aragon	Dickinson	8, 9	39	29	1889	429
Chapin	Dickinson	25, 30	40	31, 30	1880	727
Cyclops & Norway	Dickinson	5	39	29	1878	......
East Vulcan	Dickinson	10, 11	39	29	1877	......
Loretto	Dickinson	7	39	28	1893	161
Millie (Hewitt)	Dickinson	31	40	34	1881	63
Munro	Dickinson	6	39	29	1903	......
Pewabic	Dickinson	32	40	30	1890	482
Quinnesec	Dickinson	34	40	30	1878	......
Vivian	Dickinson	34	40	30	1902	32
West Vulcan, Curry & Brier Hill	Dickinson	9, 10	39	29	1879	807[a]
Clifford and Traders	Dickinson	20	40	30	......	......
METROPOLITAN TROUGH:						
Groveland	Dickinson	31	42	29	1891	45
CALUMET TROUGH:						
Calumet	Dickinson	8	41	23	1882	......

[a] Includes Cyclops, Norway and East Vulcan.

1910, WITH LOCATION, OWNERSHIP, SALES AGENTS, ETC.

Depth 1910.	Operators.	Sales agents.
850	American Boston Mining Co	M. A. Hanna & Co., Cleveland, Ohio.
515	Pittsburg & Lake Angeline Iron Co.	
200	John M. Longyear	John M. Longyear, Marquette, Michigan.
367		E. N. Breitung & Co., Cleveland, Ohio.
368		E. N. Breitung & Co., Cleveland, Ohio.
883	Republic Iron & Steel Co	M. A. Hanna & Co., Cleveland, Ohio.
2,292	Oliver Iron Mining Co.	
736	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
200	Empire Iron Co	Oglebay, Norton & Co., Cleveland, Ohio.
1,075	Republic Iron & Steel Co	M. A. Hanna & Co., Cleveland, Ohio.
186	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Open pit	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
555	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
1,070	Oliver Iron Mining Co.	
1,102	Oliver Iron Mining Co.	
1,000	Republic Iron & Steel Co	M. A. Hanna & Co., Cleveland, Ohio.
281	Cleveland Cliffs Iron Co.	
1,100	Cleveland Cliffs Iron Co.	
300	Volunteer Ore Co.	
365		E. N. Breitung & Co., Cleveland, Ohio.
470		E. N. Breitung & Co., Cleveland, Ohio.
373		E. N. Breitung & Co., Cleveland, Ohio.
812	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
686	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
Open pit	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
923	Oliver Iron Mining Co.	
1,950	Republic Iron Co	M. A. Hanna & Co., Cleveland, Ohio.
Open pit	Richmond Iron Co	M. A. Hanna & Co., Cleveland, Ohio.
698	Jones & Laughlin Ore Co.	
900	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
428	Volunteer Ore Co.	
572	Washington Iron Co	E. N. Breitung & Co., Cleveland, Ohio.
318	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
383	Cleveland Cliffs Iron Co	Cleveland Cliffs Iron Co., Cleveland, Ohio.
346	Oliver Iron Mining Co.	
413	Cleveland Cliffs Iron Co.	
135		Oglebay, Norton & Co., Cleveland, Ohio.
1,083	Oliver Iron Mining Co.	
1,522	Oliver Iron Mining Co.	
355	Penn Iron Mining Co.	
1,400	Penn Iron Mining Co.	
800	Loretto Iron Co	M. A. Hanna & Co., Cleveland, Ohio.
600	Dessau Mining Co	M. A. Hanna & Co., Cleveland, Ohio.
141	Munro Mining Co	Rogers, Brown Iron Co., Buffalo, N. Y.
941	Pewabic Co	Pickands, Mather & Co., Cleveland, Ohio.
....	Corrigan, McKinney Co	Corrigan, McKinney & Co., Cleveland, Ohio.
310	Verona Mining Co	Pickands, Mather & Co., Cleveland, Ohio.
1,500	Penn Iron Mining Co.	
....	Antoine Ore Company.	
275	Groveland Mining Co	Lake Erie Ore Co., Cleveland, Ohio.
215	Verona Mining Co	Pickands, Mather & Co., Cleveland, Ohio.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN,

Name of mine.	Location.				First shipment.	No. of men employed.
	County.	Section.	Twp.	Range.		
Crystal Falls District:						
Tobin	Iron	30	43	32	1901	......
Armenia	Iron	23	43	32	1889	84
Bristol	Iron	19	43	32	1892	206
Dunn	Iron	1	42	33	1887	135
Genesee	Iron	29,30,31	43	32	1902	......
Great Western	Iron	21	43	32	1882	283
Hemlock	Iron	4	44	33	1891	143
Hollister	Iron	13	43	33	1890	72
Mansfield	Iron	17, 20	43	31	1890	95
McDonald	Iron	23	43	32	1909	......
Michigan	Iron	9	44	33	1893	18
Iron River District:						
Tully	Iron	36	49	35	1910	88[1]
Baker	Iron	31	43	34	1909	......
Berkshire	Iron	6	42	34	1908	51
Caspian	Iron	1	42	35	1903	209
Chatham	Iron	35	43	35	1907	88
Davidson No. 1	Iron	23	43	35	......	76
Davidson No. 2	Iron	14	43	35	......	
Fogarty	Iron	1	42	35	1907	222[2]
Hiawatha	Iron	35	43	35	1893	......
Wauseca	Iron	23	43	35	1910	......
Nanaimo	Iron	26	43	35	1886	......
Osana	Iron	23	43	35	1907	142
Riverton	Iron	1, 35, 36	42, 43	35	1898	......
Tully	Iron	36	43	35	1910	88[1]
Youngs	Iron	12	42	35	1905	165
Chicagon	Iron	26	43	34	1911	......
Zimmerman	Iron	7	42	34	1908	40
Baltic	Iron	7	42	34	1901	222[2]
Gogebic Range:						
Anvil	Gogebic	14	47	46	1887	......
Asteroid	Gogebic	13	47	46	1906	......
Ashland	Gogebic	22	47	47	1885	267
Brotherton	Gogebic	9	47	45	1886	175
Castile	Gogebic	10	47	45	1906	163
Colby	Gogebic	16	47	46	1884	70
Eureka	Gogebic	13	47	46	1890	......
Ironton	Gogebic	17	47	46	1886	573
Mikado	Gogebic	18	47	45	1895	157
Newport	Gogebic	24	47	47	1886	1,277
Norrie-Aurora	Gogebic	22, 23	47	47	1884	1,245
Puritan	Gogebic	17	47	46	1886	79
Sunday Lake	Gogebic	10	47	45	1885	153
Tilden	Gogebic	15	47	46	1891	298
Yale	Gogebic	16	47	46	1901	195

[1] Baker and Tully. [2] Baltic and Fogarty.

1910, WITH LOCATION, OWNERSHIP, SALES AGENTS, ETC.

Depth 1910.	Operators.	Sales agents.
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
900	Bristol Mining Co................	Oglebay, Norton & Co., Cleveland, Ohio.
135	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
935	Hemlock River Mining Co........	Pickands, Mather & Co., Cleveland, Ohio.
500	Hollister Mining Co..............	M. A. Hanna & Co., Cleveland, Ohio.
1,189	Oliver Iron Mining Co.	
240	McDonald Mining Co.............	The Lake Erie Ore Co., Cleveland, Ohio.
541	Oliver Iron Mining Co.	
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
365	Brule Mining Co.................	Oglebay, Norton & Co., Cleveland, Ohio.
292	Verona Mining Co...............	Pickands, Mather & Co., Cleveland, Ohio.
500	Brule Mining Co.................	Oglebay, Norton & Co., Cleveland, Ohio.
450	Davidson Ore Mining Co.	
150	Davidson Ore Mining Co.	
255	Verona Mining Co...............	Pickands, Mather & Co., Cleveland, Ohio.
665	Munro Mining Co................	The Rogers, Brown Iron Ore Co., Buffalo, N. Y.
301	Mineral Mining Co...............	Pickands, Mather & Co., Cleveland, Ohio.
362	Mineral Mining Co...............	Pickands, Mather & Co., Cleveland, Ohio.
428	Mineral Mining Co...............	Pickands, Mather & Co., Cleveland, Ohio.
696	Oliver Iron Mining Co.	
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
419	Huron Iron Co...................	The Lake Erie Ore Co., Cleveland, Ohio.
500	Munro Mining Co.	
600	Spring Valley Iron Co	
600		
1,700	Newport Mining Co..............	M. A. Hanna & Co., Cleveland, Ohio.
884	Castile Mining Co...............	Oglebay, Norton & Co., Cleveland, Ohio.
1,324	Cleveland Cliffs Iron Co..........	Cleveland Cliffs Iron Co., Cleveland, Ohio.
1,075	Brotherton Iron Mining Co.......	Pickands, Mather & Co., Cleveland, Ohio.
1,111	Castle Mining Co................	Oglebay, Norton & Co., Cleveland, Ohio.
....	Corrigan, McKinney Co..........	Corrigan, McKinney Co., Cleveland, Ohio.
1,173	Castile Mining Co...............	Oglebay, Norton & Co., Cleveland, Ohio.
....	Corrigan, McKinney Co.,.........	Corrigan, McKinney Co., Cleveland, Ohio.
938	Verona Mining Co...............	Pickands, Mather & Co., Cleveland, Ohio.
2,200	Newport Mining Co..............	M. A. Hanna & Co., Cleveland, Ohio.
1,670	Oliver Iron Mining Co.	
1,264	Oliver Iron Mining Co.	
1,020	Sunday Lake Iron Co............	Pickands, Mather & Co., Cleveland, Ohio.
1,406	Oliver Iron Mining Co.	
1,780	Lake Superior Iron & Chemical Co.	Oglebay, Norton & Co., Cleveland, Ohio.

PIG IRON INDUSTRY IN MICHIGAN.

BY ALBERT E. WHITE.[1]

CONTENTS.

CHAPTER I.

INTRODUCTION. PRODUCTION.

Because of the vast iron ore wealth of Michigan, there is no question before the people of the State today of greater interest than that pertaining to the use of these selfsame iron ores. Hitherto it has been true that the majority of ores mined in the State have been shipped to points outside of the State's domains for smelting. This tendency has been due to several causes. Important among these are the facts that there are points such as those existing in Chicago, Cleveland, Buffalo, Pittsburg, etc., which are nearer the points of actual steel consumption than any localities found in

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Michigan. It is of course true that it is cheaper to ship a raw material such as ore than it is to ship a finished product such as steel. Combined with this reason there is the further fact that the localities mentioned above, particularly Pittsburg, are favored by being near the coal fields, and coal is a product of prime importance in the production of iron or steel. This feature may be noted by the fact that in the production of one ton of coke pig iron—and over 90% of our pig iron made today is smelted with coke—approximately 2,200 pounds of coke are required. Converting this figure into coal terms it is noted that approximately 3,400 pounds of coal are required for one ton of pig iron, and for the production of steel from the raw ore from 4,000 to 5,000 pounds of coal are required for a ton of steel produced. For these reasons, the one because of location and the other because of fuel supply, and because Michigan lacks both of these essentials, it will be true that Michigan will never be a large pig iron producing center. This fact holds particularly true with reference to the production of coke pig iron in Michigan, and it will probably be many years before any further coke blast furnaces will be built other than those which are already located in Detroit at the plant of the Detroit Iron and Steel Company and the plant of the Detroit Furnace Company.

The standing of Michigan as a charcoal pig iron producing center is an entirely different question, and assumes an entirely different aspect for at the present writing she makes more charcoal pig iron than all of the other states combined. This condition is due to the fact that she has her rich ore mines and she likewise has, especially in the Northern Peninsula, large tracts of woodland which are capable of producing large quantities of charcoal for many years to come. It is true, of course, that the forests in Michigan are gradually being denuded, but it is estimated that there is enough wood in the State at the present time to keep the present number of blast furnaces in operation at their present rate for a period of fifty years. By proper conservation and growth of new trees it could very likely be true that Michigan could produce her present yearly output of charcoal pig iron for almost an indefinite period.

A conception of the importance of this industry should be gleaned from an examination of the following table which shows the yearly production of pig iron in the United States from 1854 to the present time and the part Michigan has played in this production since 1872.

PIG IRON PRODUCTION.

Year.	Michigan production.	U. S. Production.			Total.
		Charcoal.	Anthracite.	Bituminous.	
1854		342,298	339,435	54,485	736,218
1855		339,922	381,866	62,390	784,178
1856		370,470	443,113	69,554	883,137
1857		330,321	390,385	77,451	798,157
1858		285,313	361,430	58,351	705,094
1859		284,041	471,745	84,841	840,627
1860		278,331	519,211	122,228	919,770
1861		195,278	409,229	127,037	731,544
1862		186,660	470,315	130,687	787,662
1863		212,005	577,638	157,961	947,604
1864		241,853	684,018	210,125	1,135,996
1865		262,342	479,558	189,682	931,582
1866		332,580	749,367	268,396	1,350,343
1867		344,341	798,638	318,647	1,461,626
1868		370,000	893,000	340,000	1,603,000
1869		392,150	971,150	553,341	1,916,641
1870		365,000	930,000	570,000	1,865,000
1871		385,000	956,608	570,000	1,911,608
1872	86,840	500,587	1,369,812	984,159	2,854,558
1873	113,975	577,620	1,312,754	977,904	2,868,278
1874	128,965	576,557	1,202,144	910,712	2,689,413
1875	101,805	410,990	908,046	947,545	2,266,581
1876	82,477	308,649	794,578	990,009	2,093,236
1877	75,216	317,843	934,797	1,061,945	2,314,585
1878	70,853	293,399	1,092,870	1,191,092	2,577,361
1879	101,539	358,873	1,273,024	1,438,978	3,070,875
1880	154,424	537,558	1,807,651	1,950,025	4,295,414
1881	187,043	638,838	1,734,462	2,268,264	4,641,564
1882	210,195	697,906	2,042,138	2,438,078	5,178,122
1883	173,185	571,726	1,885,596	2,689,650	5,146,972
1884	172,834	458,418	1,586,453	2,544,742	4,589,613
1885	143,121	399,844	1,454,390	2,675,635	4,529,869
1886	190,734	459,557	2,099,597	3,806,174	6,365,328
1887	190,663	529,457	1,901,256	2,957,232	6,387,945
1888	190,403	598,789	1,925,729	4,743,989	7,268,507
1889	191,395	644,300	1,920,354	5,952,414	8,517,068
1890	230,769	703,522	2,448,781	7,154,725	10,307,028
1891	213,145	576,964	1,866,108	5,836,798	8,279,870
1892	184,421	537,621	1,797,113	6,822,266	9,157,000
1893	117,538	386,789	1,347,529	5,390,184	7,124,502
1894	95,171	222,422	914,742	5,520,224	6,657,388
1895	91,222	225,341	1,270,899	7,950,068	9,446,308
1896	149,511	310,244	1,146,412	7,166,471	8,623,127
1897	132,578	255,211	932,777	8,464,692	9,652,680
1898	147,640	296,750	1,203,273	10,273,911	11,773,934
1899	134,443	284,766	1,599,552	11,736,385	13,620,703
1900	163,712	299,124	1,841,857	12,253,818	13,789,242
1901	170,762	390,147	1,712,527	13,782,386	15,878,354
1902	155,213	378,504	1,115,247	16,315,891	17,821,307
1903	244,709	504,757	1,911,347	15,592,221	18,009,252
1904	233,225	337,529	1,228,140	14,931,364	16,497,633
1905	288,704	352,928	*1,300,000	*21,339,452	22,992,380
1906	369,456	433,007	1,305,094	23,313,498	25,307,191
1907	436,507	437,397	1,371,554	23,972,410	25,781,361
1908	348,096	249,146	355,009	15,331,865	15,936,018
1909	964,289	376,003	698,431	24,721,037	25,795,471
1910	1,250,103	394,377	649,082	26,255,086	27,298,545
1911	542,193	160,847	149,227	11,355,722	11,665,796

*Estimated.

Note:—These figures may not altogether tally because great difficulty was encountred in preparing the table; for at best the figures had to be obtained from many and various sources.

Michigan's production from 1906 includes the production in Indiana also. To 1906 the production is altogether charcoal. Michigan's production for 1903, 1904 and 1905 is not quite complete as it does not have the tonnage of coke pig iron made in the State during those years.

1911's figures are for the half year from January 1st to July 1st.

The figures up to 1891 are in net tons. Beginning with 1891 the figures are in gross tons.

HISTORY AND DEVELOPMENT OF THE INDUSTRY.

No notice of Michigan as a pig iron producing center was taken to any marked extent until about 1840. At that time it was reported that there were fifteen blast furnaces in the State. Many of these were doubtless forges and as such could not be credited as being true blast furnaces. They were all in the southern part of the State. From 1840 to 1850 Michigan as an iron center suffered a decline, but from 1850 to 1860 considerable progress took place in the industry. This progress consisted in the building of three new furnaces for the purpose of smelting the bog ores found in the southern part of the State and likewise in developments that took place in the Northern Peninsula. The first pig iron made in the Lake Superior region was in 1858 by Stephen R. Gay who converted a forge into a miniature blast furnace. The first regular furnace erected in this region, however, was that built by the Pioneer Iron Company in the present city of Negaunee, convenient to the well known Jackson mine. This company, which is a subsidiary of the Cleveland Cliffs Iron Company, is still in active operation, and it has been manufacturing pig iron for a longer period than any corporation doing like work within the bounds of the State. While such progress as just noted was being made in the Northern Peninsula, slight development was made in the southern portion of the State, particularly near Detroit. In that region the Eureka furnace was built in 1855 by the Eureka Iron Company with Captain E. B. Ward as President; and a furnace at Detroit, known as the Detroit Furnace, was built in 1856 by the Lake Superior Iron Manufacturing Company, with George B. Russell as President. This latter furnace, if the writer is not mistaken, is the one at present owned by the Detroit Furnace Company, and up to the past few months has been in active operation, although for the past few years it has been using coke in place of charcoal as its metallurgical fuel. The Eureka Furnace has been one of the best known furnaces in the State and in its day has been one of the most successful of blast furnaces. The difficulty of getting ore to the furnace and the great difficulty it encountered, because of its location, in getting fuel at a reasonable cost, are the reasons why, after a long and successful operation, the furnace went out of blast.

From this time on, a minute study of the history of the pig iron industry in Michigan would, in reality, prove to be a long and probably tedious presentation of facts. Many furnaces have been built and after a short operation have either been sold to other parties, dismantled and taken elsewhere, or else completely shut down. (There has probably been less consolidation among the makers of charcoal pig iron than in any other branch of the iron and steel business. The writer knows of no definite attempt to unite the charcoal furnaces together under one strong head until the formation of the Lake Superior Iron and Chemical Company in 1910.) Such fluctuations and variations have largely been due, probably, to the lack of a sufficient supply of charcoal at any one place for a long period. It has proved more wise to either dismantle a plant or else move it to a fresh charcoal center when the supply of charcoal disappeared from the old location, than to bring charcoal to the plant from long distances. In other words, the policy has been to bring the furnace to the charcoal rather than the charcoal to the furnace.

Because of the above reasons, pig iron production in Michigan from 1870 to 1880 and from 1880 to 1890 sustained no great improvement. As regards quantity it is true that the State sent forth nearly as much pig iron as it ever had; in fact, for the most part, the quantity produced slightly increased although the percentage of increase was no greater than the percentage of increase throughout the country. For example, this State in 1880 ranked fourth as a pig iron producing center; in 1890 it had dropped to 8th place; and in 1900 it was still 8th; while in 1910 it was ranked as the 7th State, due largely to the output of the Detroit Iron and Steel Company's two coke furnaces at Detroit. It was from 1890 to 1900 that more changes of management took place than in any other period. The early part of the ten years was a period of almost continual depression, and pig iron manufacturers in Michigan suffered more financial embarrassment than they have in any of the other periods.

The last ten years have seen sort of a revolution regarding the manufacture of pig iron from charcoal. In the early days wood was cut and charcoal made from it without in any way considering the by-product values found in wood, such a wood alcohol, calcium acetate, etc. It had largely been a question of cutting wood, carbonizing it, and then smelting iron ore with it as a quick and efficient means of clearing ground and at the same time getting financial returns. In many cases the investment idea was emphasized more than the thought of clearing the ground. Such a condition encouraged men to go into the proposition to just as light an extent as possible, without giving any concern as to the future of the business. This attitude, of necessity, led to poor equipment, and an absence of all permanency. Because of these facts pig iron could be made with a high market but it could not be made at a profit with a low market.

The poor logic of this attitude was after a time realized and the companies that are in business today are doing all in their power to put the industry on a permanent footing. By means of charcoal and retort by-product kilns they are endeavoring to recover from the wood all the values possible. They are cutting the wood and developing new growths with a proper attitude toward conservation and they are equipping their furnaces with such mechanical appliances as will tend to materially reduce costs.

Up to 1903 the entire amount of pig iron made in Michigan was smelted with charcoal. For that reason everything which has been said in regard to the history of the industry in the preceding statements has related entirely to charcoal plants. In 1902 the Detroit Iron and Steel Company had its formation and in 1903 it put in blast a large merchant coke pig iron furnace in Detroit. This plant has been operated continuously since that time, with the addition in 1910 of another merchant coke furnace. Likewise in 1906 the Detroit Furnace changed hands, and since that time it has been producing coke pig iron.

With this brief resume we are taken down practically to the present writing. A tabulated list of the furnaces at present in operation or capable of being operated is presented, and a somewhat detailed statement with regard to each plant is also added.

BLAST FURNACES IN MICHIGAN.

Name of furnace.	Name of company.	Location of furnace.	Activity.	Type of fuel.	Activity of furnace.
Antrim	Antrim Iron Company	Antrim	In blast	Charcoal	115 tons
Cadillac	Mitchell-Diggins Iron Co	Cadillac	In blast	Charcoal	100 tons
Carp	Pioneer Iron Company	Near Marquette	Idle	Charcoal	50 tons
Chocolay	Lake Superior Iron & Chemical Co	Harvey	Idle	Charcoal	70 tons
Detroit	Detroit Furnace Company	Detroit	Idle	Coke	75 tons
East Jordan	East Jordan Furnace Company	East Jordan	In blast	Charcoal	80 tons
Elk Rapids	Lake Superior Iron & Chemical Co	Elk Rapids	Idle	Charcoal	110 tons
Gladstone	Pioneer Iron Company	Gladstone	In blast	Charcoal	....
Manistique	Lake Superior Iron & Chemical Co	Manistique	Idle	Charcoal	110 tons
Marquette	Pioneer Iron Company	Marquette	In blast	Charcoal	120 tons
Newberry	Lake Superior Iron & Chemical Co	Newberry	Idle	Charcoal	80 tons
Pine Lake	Lake Superior Iron & Chemical Co	Boyne City	In blast	Charcoal	110 tons
Spring Lake	Spring Lake Iron Company	Fruitport	Idle	Charcoal	75 tons
Stevenson	Stevenson Charcoal Iron Co	Wells	Building	Charcoal	60 tons
Zug Island A	Detroit Iron & Steel Company	Detroit	In blast	Coke	300 tons
Zug Island B	Detroit Iron & Steel Company	Detroit	In blast	Coke	325 tons

DETAILS OF BLAST FURNACES IN MICHIGAN.

Name of furnace.	Lines of furnace.					Twyeres.		Stoves.			
	Heighth.	Hearth Depth.	Bosh Diam.	Hearth Diam.	Throat Diam.	No.	Size.	No.	Size. Heighth.	Size. Diam.	Kind.
Antrim	60′	6′	12′	6′	7′	8	4″	2	....	....	Durham pipe.
Cadillac	65′	6′	11′ 4″	7′ 8″	7′ 6″	5	4″	3	60′	16′	Kennedy Brick.
Carp	58′	....	10′	....	....	....	....	....	....	....	Durham Pipe.
Chocolay	40′	....	8′	....	....	....	....	2	....	....	Durham Pipe.
Detroit	62′	7′ 8″	12′ 6″	7′ 6″	7′ 4″	7	3½″	3	....	....	Durham Pipe.
East Jordan	60′	6′ 6″	10′	6′	6′	5	4½″	2	60′	16′	Three-pass Brick.
Elk Rapids	64′	6′ 3½″	12′ 6″	7′ 6″	7′	....	....	2	....	....	Durham Pipe.
Gladstone	60′	....	12′	....	....	5	5″	3	70′	16′	Roberts-Cowper Brick.
Manistique	59′ 6″	5′ 4″	12′ 6″	7′	7′ 6″	....	....	2	....	....	Durham Pipe.
Marquette	70′	....	13′	....	....	....	....	3	....	....	Roberts-Cowper Brick.
Newberry	60′	6′	12′	7′ 6″	7′ 6″	4	4″	2	....	....	Durham Pipe.
Pine Lake	62′ 9″	6′ 8″	12′	7′ 2″	6′ 6″	....	....	2	....	....	Two Pass Brick.
Spring Lake	50′	....	11′	....	....	....	....	2	....	....	Durham Pipe.
Stevenson	60′	....	10′	....	....	....	....	2	....	....	Two Pass Brick.
Zug Island A	78′	6′	18′ 8″	13′	12′ 6″	10	5″	4	83′	20′	Garrett-Cromwell Brick.
Zug Island B	80′	7′	18′ 6″	12′ 6″	12′ 6″	12	5″	4	85′	12′	Nelson-McKee Brick.

CHAPTER II.

DETAILS REGARDING THE BLAST FURNACES IN MICHIGAN.

Because of the great diversity between charcoal pig iron and coke pig iron there will be made in this article no attempt to draw comparisons between the two. Each one will be treated independently and by itself. Each type of pig iron has its own place and there is little question but what a ready market will be found for the sale of charcoal pig iron if the manufacturers of this self same article are willing to place it on a competing basis as regards price, with that of coke pig iron.

Regarding the last point, such a condition is almost true at the present writing for the selling price of charcoal iron in Chicago today is but $16.50 a ton while the selling price of coke pig iron in the same center is $14.00 per ton.

That there can be but little profit in the manufacture of either product when the investment necessary for the business is considered and the amounts of off iron which are made of necessity no matter how carefully the smelting is watched, may be gleaned by studying the following cost sheets.

Charcoal pig iron.		Coke pig iron.	
Ore, 2.05 tons at $2.50	$5 13	2.05 at $2.50	$5 13
Charcoal or coke, 90 bu. at $0.06	5 40	1.1 at 4.50	4 95
Stone, .25 tons at $1.00	25	.5 at 1.00	50
Operating and repairs	2 50		1 25
Freight	1 50		....
Cost per ton of pig iron at Chicago	$14 78		$11 83

Because of the diversity, however, each type of iron will be given its own respective place.

CHARCOAL FURNACES.

With the selling price of pig iron as it is at the present time there is absolutely no question but were the by-product values of wood disregarded there would be no manufacture of charcoal pig iron in Michigan today, for if there was, the industry would be carried out at a loss and such a condition could not long exist.

Every charcoal plant operating today either owns its by-product recovery plant or else it is in such close union with a plant getting by-product values from wood as to be assured of a definite and regular supply of charcoal at a reasonable figure; the cost of the charcoal varying as the price of the charcoal pig iron varies.

There are two types of kilns extensively used in manufacturing charcoal. The one is a beehive kiln capable of containing from 60 to 90 cords of wood at a time, and producing approximately 45 bushels of charcoal per cord of wood. The operating cost for making charcoal is approximately 1½c per bushel and a kiln of this type will cost approximately $600.00. It takes 30 days to "turn" a kiln. By "turning" is meant the filling of the kiln, the carbonizing of the wood, the cooling of the wood and the discharging of the wood from the kilns. In a retort kiln, wood is placed on steel buggies or carriers which hold from 8 to 10 cords. The loaded buggy remains in the retort chamber for 24 hours, after which time the heat in the retort has driven out all the volatile matter and has carbonized the wood. The retorts are steel chambers 47′ long, 96″ high and 78″ wide. They are heated by the combustion of otherwise useless waste gases that come off from the carbonizing of the wood and likewise in emergencies they can be heated by the burning of wood. Combustion takes place in a chamber surrounding the retort. The flame does not hit the wood in the retort but heat is transmitted to the wood by radiation. This is directly the reverse of the action which takes in the beehive kiln where a certain quantity of the wood in the kiln is burned, solely for the purpose of giving enough heat for the carbonizing of the rest of the wood in the kilns.

Most all of the furnaces are hand filled, the one exception being Pioneer No. 2 Furnace at Marquette. Likewise in most all of the plants the stock house and stoves and storage bins are placed under shelter. This is primarily due to the fact that because of the cold, particularly with regard to the stoves, it has been found advisable to have them covered up, for in so doing a considerable loss of heat due to radiation is avoided. The covering of the stock bins is to prevent the ore from freezing as much as possible. It has been found cheaper to cover up these stocks of ore than it has been to keep gangs of men busy all winter digging out the frozen ore. This can be done somewhat more handily than it can in the case of furnaces making larger tonnages of pig iron; for with charcoal furnaces a storage stock house capacity of from 60,000 to 75,000 tons is all that is necessary, while in some of the larger units that are making pig iron in the Pittsburg or Chicago districts storage capacities of from 750,000 to 1,500,000 is hardly more than adequate. Shelter storage bins for tonnages of this latter type is, of course, out of the question. It was interesting to note that the stoves of the Mitchell-Diggins Iron Company at Cadillac were unprotected, and Mr. Lamoureaux, the Superintendent of that plant, stated that he experienced no difficulty in getting what heat he wished from the stoves.

Throughout, all of the charcoal furnaces cast in sand. For the most part the tapping hole is hand plugged rather than with a Gunnell's gun.

ANTRIM IRON COMPANY.

The Antrim Iron Company was organized in Michigan in 1886 with a capital stock of $350,000.00. Its officers are W. Bernhardt, President; J. C. Holt, Vice President and Treasurer; H. J. Bennett, Secretary; and N. M. Langdon, Manager.

The furnace was built in 1883 or 1884 by Mr. Otis, who was financially backed by Mr. Cherry of Chicago. On the latter gentleman's failure in 1884-5 the plant went into the receiver's hands, with Mr. Bernhardt as receiver. Mr. Otis, however, was permitted to pull the furnace out of the hole. Mr. T. J. O'Brien was President of the Company from that time until he resigned to enter the United States diplomatic circles as Minister to Japan.

Regarding the furnace proper, it is 60′ high and it has a 12′ bosh; the diameter of the throat is 7′ and of the hearth is 6′, with a hearth depth of 6′. It is hand filled and is capable of producing 115 tons of pig iron per day; but because of dull market conditions but 80 tons of pig iron is being produced daily at the present writing. It has 8 twyeres, and the diameter of the blow pipes at the nozzle of these twyeres is 4 inches. The blast pressure varies from 5 pounds to 7½ pounds to the square inch; an increase in blast pressure of necessity implying an increase in pig iron production. About 6,500 cubic feet of air is blown into the furnace per minute, and an average of 91 bushels of charcoal is used per ton of pig produced.

There is one double Durham iron pipe stove which heats the blast up to about 900° F. There are 18 U-pipes in the stove. There is also a spare stove. The blast is furnished by one vertical Weimer blowing engine, with a piston displacement in the blowing tub of 72″ x 48″. There are 6-150 H. P. and 2-200 H. P.

Wicks vertical water tube boilers. These are both gas fired with waste gases from the blast furnace and wood fired.

The charcoal is obtained from 56-55-cord beehive charcoal kilns, and 20-80 cord charcoal kilns of the same type. Wood alcohol and acetate of lime is secured from the volatile matter given forth in the carbonizing of the wood. Connected with the plant is a saw mill wherein the best of the lumber cut is sawed into shape and sold for building purposes.

EAST JORDAN FURNACE COMPANY.

The East Jordan Furnace Company was organized in Michigan, November 24, 1909, with a capital stock of $375,000.00. Its officers are Charles H. Schaffer, President; F. B. Baird, Vice President; and W. J. Ellson, Secretary and Treasurer. The furnace is located at East Jordan, Michigan, on the Detroit and Charlevoix, and East Jordan and Southern Railroads.

A large portion of the plant came from Principio, Maryland. A plant had at one time been in operation at that point making charcoal pig iron, but because of market conditions and the failure to have at hand a supply of charcoal it had to be abandoned. It was bought en masse by Michigan parties and moved to East Jordan.

The height of the furnace is 60′ and the diameter of the bosh is 10′. The diameter of the throat is 6′ and of the hearth is likewise 6′. The depth of the hearth is about 6′ 6″. The furnace is producing daily at the present time about 60 tons of pig iron. It could produce more, but because of the present dull market and because of lack of fuel, as the chemical plant from which the company derives its charcoal can give them but enough for 60 tons of pig iron per day, it is unable at present to give a greater tonnage. The furnace is hand filled. It consumes approximately 93 bushels of charcoal per ton of pig. There are five twyeres, the nozzle diameter of the blowpipe being 4½″.

Connected to the furnace are two 3-pass stoves, each one of which is 60′ high and 16′ in diameter. The blast is heated to from 950° F. to 1,100° F. Stoves are changed every 1½ hours. The blast pressure is 3½ to 4 pounds. The blast is furnished by a Weimer blowing engine which makes from 15 to 17 revolutions per minute. From 7,500 to 8,000 cubic feet of air is supplied to the furnace per minute. For generating power there are 6-250 H. P. water tube boilers of the Wicks type. Blast furnace gas and refuse from the saw mill is used as the boiler fuel.

The charcoal used in the furnace is obtained from the East Jordan Chemical Company. This company have 14-8-cord retort kilns and make the usual by-products from the wood consisting of wood alcohol and calcium acetate. The furnace plant is in no way connected with the chemical plant, but the chemical plant is under contract to supply to the furnace plant a definite amount of charcoal, and this feature assures the furnace company the supply of charcoal necessary for its operation.

LAKE SUPERIOR IRON AND CHEMICAL COMPANY.

The Lake Superior Iron and Chemical Company was organized in July, 1910, under the laws of the State of Michigan, with a capital stock of $10,000,000.00. Its present officers are John Royce, President; W. H. Matthews, Vice President and General Manager; L. F. Knowles, Secretary; and A. Van Oss, Treasurer. It is a consolidation of many of the charcoal plants scattered throughout Michigan, and it is putting many modern methods and practices into the manufacture of pig iron.

The company owns the Manistique furnace at Manistique, Michigan, the Newberry furnace at Newberry, Michigan, the Elk Rapids furnace at Elk Rapids, Michigan, the Pine Lake furnace at Boyne City, Michigan, the Chocolay furnace at Chocolay, Michigan, and the Hinkle furnace at Ashland, Wisconsin. With regard to the furnaces in Michigan but one, the Pine Lake stack, is operating at the present time. The Hinkle furnace is also operating but as its location is outside of the State it will not be treated or spoken of at further length in this article. The Manistique and Newberry and Elk Rapids furnaces will probably be blown in within the next few weeks, however. Extensive repairs and changes have been going on at these two plants and that fact for the most part accounts for their present idleness. The Chocolay furnace is so old and antiquated that it is extremely doubtful if it will ever again see further operation.

CHOCOLAY FURNACE.

The Chocolay furnace is an old stone stack formerly owned and operated by the old Lake Superior Iron and Chemical Company —now known as the Northern Iron and Chemical Company—and acquired in July, 1910, by the present Lake Superior Iron and Chemical Company. It formerly had an open top and boilers were placed on a fourth floor in order to more efficiently use the waste heat from the furnace. It has been owned by many different parties and it has been rebuilt and remodelled a great many times. From its early erection, however, it has proved to be a failure from a business standpoint. As soon as the present parties bought it they shut it down and it will not be operated until such a time as the price of pig iron rises to a point where a profit in its operation can be assured.

The stack itself is 40′ high and has a bosh 8′ in diameter. It is capable of producing 70 tons of pig iron per day. The blast is heated by means of two small Durham iron pipe stoves. The old blowing engine, has a piston displacement of 48″ x 72″ and makes from 11 to 13 revolutions per minute.

When operating it made car wheel and malleable pig iron, using charcoal as its fuel.

ELK RAPIDS FURNACE.

The Elk Rapids furnace, at present owned by The Lake Superior Iron and Chemical Company, is located on the Pere Marquette Railroad at Elk Rapids, Michigan. The furnace proper has been out of blast since early in the spring of 1911. Since that time, however, remodelling changes have been going on and it is very probable that the early spring will see the furnace in operation again.

The stack itself is 64′ high and it has a 12′ 6″ bosh. The throat is 7′ in diameter and the hearth is 6′ 3½″ deep and 7′ 6″ in diameter. Connected to the furnace are two iron stoves, one is 18′ x 28′ and another 18′ x 24′; each one has 21 pipes. There is one Weimer blowing engine having a capacity of 8,000 cubic feet per minute, also there is one old engine with a capacity of from 5,000 to 6,000 cubic feet per minute. Power is derived for the running of the blowing engines, pumps, etc., by four return type tubular boilers of 100 H. P. each.

Located close to the furnace are 60-60-cord beehive charcoal kilns. These make the charcoal used in the blast furnace and likewise furnish the volatile gases from which the chemicals such as wood alcohol and calcium acetate are obtained.

MANISTIQUE FURNACE.

The Manistique furnace, located as it is at Manistique, Michigan, has excellent railroad facilities by being on the lines of the Chicago, Milwaukee, and St. Paul, Sault Ste. Marie, and Ann Arbor Railroads. This stack was originally built by the Perry

Chemical Company about 1890 and was acquired in 1910 by the present Lake Superior Iron and Chemical Company.

It has been out of blast since June, 1910, but it will probably go in blast again about June, 1912. Extensive changes have been made in the plant, and by the time it is ready to go in blast it will, without doubt, be one of the best equipped charcoal pig iron plants in the country.

The furnace is 59′ 6″ high with a 12′ 6″ bosh diameter. The diameter of the throat is 7′ 6″ and of the hearth is 7′, with a hearth depth of 5′ 4″. Its rated daily capacity is from 110 to 120 tons of pig iron. The furnace is hand filled. The blast is heated by Durham hot blast pipe stoves which heat the air up to approximately 960° F.

Its blowing engine is of the Nordberg cross compound horizontal type with a rated capacity of 10,000 cubic feet per minute. There is also a Weimer vertical engine which has a capacity of 8,000 cubic feet per minute. The furnace proper will use about 7,600 cubic feet of air per minute under a pressure of 6½ pounds. Six Wicks vertical water tube boilers furnish a total of 1500 H. P. for the running of the blowing engines, pumps, and the other mechanical appliances around the furnace. They are equipped so as to use the waste gases from the blast furnace.

As new installation there is being erected a charcoal kiln plant very similar in detail to that which is found at the Newberry furnace and which will be discussed at further length in the description pertaining to the Newberry furnace.

NEWBERRY FURNACE.

Located on the Duluth, South Shore and Atlantic Railroad, in the town of Newberry, is a charcoal blast furnace known as the Newberry furnace. In 1910 this was acquired by the Lake Superior Iron and Chemical Company. It has been erected for a considerable period and has been in operation off and on for many years. Extensive repairs and alterations have been made recently and in fact are still being made. It is the expectation that about February 1st it will be in such shape as to permit its being blown in.

The furnace is 60′ high with a 12′ bosh; the diameter of the throat is 7′ 6″ and of the hearth is 7′ 6″. The height of the hearth is 6′. It is hand filled and has a capacity of 80 tons of pig iron per 24 hours. There are four twyeres, each one of which has a diameter at the end of the blow pipe of 4″. It is expected that about 87 bushels of charcoal or the equivalent of two cords of wood will make a ton of pig iron.

Attached to the furnace are two Durham iron pipe stoves, each one of which has 16 pipes. It is the intention to heat the blast to a temperature of 950° F., and use a pressure of 5½ pounds. The blast is furnished by one Nordberg cross compound horizontal engine having a capacity of 10,000 cubic feet. There is also a Weimer blowing engine of 8,000 cubic feet capacity that can be used as a spare. In the boiler house are found 8 horizontal tubular boilers giving a total of 1,200 H. P.

When completed this plant will be equipped so as to get to as great an extent as possible all of the values that are found in the wood. Timber is brought to the company's saw mill and there sawed and such pieces as are of proper grade are sold for building purposes. The refuse from the mill, consisting as it does of odd ends, sides, and slabs too small for sale as lumber, are taken to the company's charcoal ovens for conversion into charcoal, wood alcohol, and calcium acetate.

The old plant consisted of 54-100-cord brick charcoal kilns. In using these it takes about 30 days to fill, fire, and turn a beehive charcoal kiln. The entire process is known technically as "turning." These kilns will still be used but only to a limited extent. In fact they will only be used for the using up of the large wood.

The new installation consists of 20 retort kilns which are capable of daily carbonizing 160 cords of wood. Such an installation makes this the largest charcoal retort kiln plant in the world. Besides the 20 retort burning kilns there are 40 retorts for cooling, 20 of which are for the hot coals and 20 for the cooler coals. In cold weather it will probably be necessary to operate but the first set of coolers. Each retort is 47′ long, 78″ wide and 96″ high. The volatile gases as they come from the burning of the wood give a light distillate which is essentially wood alcohol and also a heavy distillate. This latter product by further distillation gives tar and a product which, when treated with lime, gives calcium acetate. For the purpose of carrying out the chemical action a modern by-product recovery plant is now nearing completion.

PINE LAKE FURNACE.

Formerly owned by the Boyne City Iron and Chemical Company, this furnace which is located at Boyne City was acquired in 1910 by the Lake Superior Iron and Chemical Company. It is located on the Boyne City and Southeastern Railroad. It is the one furnace owned by the Lake Superior people, of all those located in Michigan, which is at present in operation.

The pig iron plant proper, which we are chiefly interested in, consists of a furnace, cast house and stock house. The stack is 62′ 9″ high with a bosh 12′ in diameter. The diameter of the throat is 6′ 6″ and of the hearth is 7′ 2″. The depth of the hearth is 6′ 8″. The furnace has two 2-pass brick stoves, each one of which is 60′ high and 12′ in diameter. It has a vertical blowing engine of 8,000 cubic feet capacity of the Waddington, McConnell, and Stevenson type. There are also three Wicks boilers furnishing a total of 750 H. P.

The furnace, which was originally blown in on January 1st, 1904, was in almost continuous blast for a period of 6 years and 8 months from that time. It was blown out on September 1st, 1911, for relining, but was blown in again on December 5th, 1911. The rate of daily output of the plant is 80 tons, and 88 bushels of charcoal are used per ton of iron made. The furnace is tapped every six hours. The limestone used is that obtained from the Petoskey Crushed Stone Company. Old range ores make up the basis of the burden. A charge at this furnace consists of two buckets of ore (1,250 pounds), two buckets of charcoal (500 pounds) and 60 pounds of stone.

The charcoal used comes from that furnished by the Boyne City Chemical Company. At the plant of this latter company there are 14 retort kilns of 10 cords of wood capacity each. But for the stunted supply of charcoal at the furnace there is little doubt but what the furnace could raise its daily capacity to a much higher degree than that stated in a preceding paragraph.

MITCHELL-DIGGINS IRON COMPANY.

In 1904 the Mitchell-Diggins Iron Company was organized in Michigan with W. W. Mitchell, President; J. C. Ford of Fruitport, Vice President and Secretary; and Fred A. Diggins, Treasurer. The plant is located at Cadillac on the Grand Rapids and Indiana and Ann Arbor Railroads.

This plant, more than all others at present making charcoal pig iron, is strikingly similar to coke blast furnaces. This feature is probably accounted for because Julian Kennedy, a prominent coke blast furnace engineer, was the designer of this plant. Its erection at Cadillac is accounted for by the fact that there are two large saw mills at that point and two wood chemical plants known respectively as the Cadillac Chemical Company and Cummer-

Diggins Company. These firms had no adequate outlet for the charcoal which they produced as a by-product to the wood alcohol and calcium acetate values, and in consequence they assured the builders of the furnace plant a reasonable supply of charcoal at a reasonable cost if the furnace would take off their hands the supply of charcoal which they are continually making.

The stack has a height of 65′ and a bosh diameter of 11′ 4″. The diameter of the throat is 7′ 6″, the diameter of the hearth is 7′ 8″ and the depth of the hearth is 6′. There are five twyeres, each one of which has a blowpipe diameter at the nozzle of 4″. The blast pressure is about 6½ pounds. The capacity of the furnace is from 90 to 100 tons of pig iron per day.

The stoves, which are three in number, are 60′ high and 16′ in diameter and are of the Kennedy 2-pass type. They are exposed to the air and are the only charcoal stoves in Michigan which are constructed without shelter. The stoves are changed every two hours and the blast is heated up to from 1,100° to 1,250° F. There are three boilers, each one of 250 H. P. They are of the K. Hall horizontal type, and are equipped for using the waste gases from the blast furnace and likewise for burning coal. The blast is furnished by one Tod vertical blowing engine, with a rated capacity of 10,000 cubic feet per minute.

THE PIONEER IRON COMPANY.

This is one of the oldest pig iron producing companies in Michigan for it was on April 2nd, 1857, that the company was organized with a capital stock of $125,000. It is a subsidiary to the Cleveland-Cliffs Iron Company. The officers at the present writing consist of G. A. Garretson, President; Wm. G. Mather, Vice President; E. V. Hale, Secretary; F. A. Morse, Treasurer; R. C. Mann, Auditor; and Austin Farrell, General Manager. The Board of Directors is made up of Wm. G. Mather, E. V. Hale, G. A. Garretson, J. H. Hoyt, Samuel Mathers and J. H. McBride.

This company controls three furnaces, two near Marquette and one at Gladstone, Michigan. Two of the furnaces are active; the one at Gladstone and one at Marquette. Detailed information in regard to these furnaces is found below.

CARP RIVER FURNACE.

In 1905 the Pioneer Iron Company purchased from Schaffer and Gray a blast furnace, located at Carp River, that is known as the Carp River Furnace. It was operated continuously throughout the years 1905, 1906 and 1907, making a brand of iron that is known as "Excelsior." It has not been operated since, however, because of the low price that charcoal pig iron has been bringing the past few years. In fact, it is quite probable that the furnace will never see further operation again as it is not equipped with many of the modern appliances and thus is in a condition preventing it from making pig iron at an economical figure. In fact the price of the iron would have to undergo a marked rise before its blowing in would be warranted.

The furnace itself is 58′ high and it has a bosh 10′ in diameter. It is filled by hand and is capable of producing about fifty tons of pig iron per day.

The fuel used is charcoal obtained from the company's beehive charcoal kilns of which there are 43 in number.

NO. 1 FURNACE AT GLADSTONE.

This furnace was built in 1896 by the Pioneer Iron Company at Gladstone, Michigan, but a short distance from Lake Michigan and near the port of Escanaba.

The furnace itself is 60′ high and has a bosh 12′ in diameter. It has a rated daily capacity of approximately 110 tons of pig iron, the brand of which is known as "Pioneer." The furnace is filled by hand and has a single bell with a Weymer seal. It uses 4 pounds air pressure, has five twyeres with a 5″ diameter blowpipe nozzle. Connected with the furnace are three Roberts-Cowper stoves, each one approximately 70′ high and 16′ in diameter.

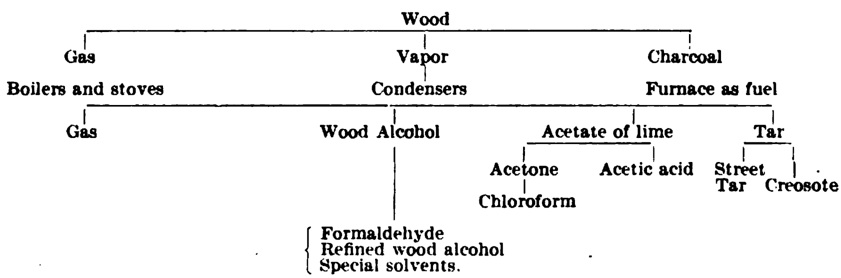
As a fuel the furnace uses charcoal obtained from 70 beehive charcoal kilns and 10 retort kilns. The wood put into the kilns is cut by the company's lumbering department. The smoke caused by the manufacture of the charcoal is used in the company's chemical plant for the production of various chemical products, chief of which are acetate of lime and wood alcohol.

NO. 2 FURNACE AT MARQUETTE.

This furnace was erected in 1903 by the Pioneer Iron Company, a subsidiary of the Cleveland Cliffs Iron Company. It is built very closely along the line of the company's furnace at Gladstone. The plant, however, is somewhat more modern and has several improvements, chief of which is Gayley's dry blast.

The furnace itself is 70′ high and has a 13′ bosh. It averages about 120 tons of pig iron per day, making a brand known as "Marquette." A blast of 6½ pounds pressure is carried which gives a volume of 7,000 cubic feet per minute. The air is supplied by a double cross compound Southwark engine. The furnace is skip filled and has a Roberts revolving top. Connected with the furnace are three Roberts-Cowper stoves, each one 70′ high and 16′ in diameter. When but two of these stoves are used they are changed every two hours while with three stoves in use they are changed every 1½ hours. They heat the blast to a temperature ranging from 1,000° to 1,100° F.

For fuel charcoal is used, obtained from 86 kilns operated by the company and which are filled with wood cut by the lumbering department of the Cleveland-Cliffs Iron Company. Of the kilns there are 80 that are known as 80 cord kilns, each one of which is capable of producing about 3,500 bushels of charcoal per turn, and there are 6 kilns with a capacity of 90 cords capable, therefore, of producing a somewhat larger quantity of charcoal. The smoke coming from the kilns as the result of a charring of the wood is converted into various chemical by-products, chief of which is alcohol, formaldehyde, acetone and acetic acid. The flow sheet of a portion of this particular conversion which may be of interest is as follows:



In 1910 the plant was equipped with a Gayley dry blast, not so much for the purpose of reducing the charcoal consumption in the blast furnace as to enable the furnace operator to have uniform conditions in his furnace and thus assure the management of a uniform quality of pig iron. The expense attached to the installation seemed justified, for with pig iron selling at such a close margin it was necessary to take advantage of all methods which would tend toward the assurance of a uniform and standard quality of pig. At the present time about 92 bushels of charcoal are used per ton of pig iron produced.

A. EAST JORDAN FURNACE.

B. NEWBERRY FURNACE.

A. ANTRIM IRON FURNACE.

B. FURNACE AND CHEMICAL WORKS, ANTRIM, MICHIGAN.

The ores are some of those mined by the Cleveland Cliffs Iron Company at its various mines located in northern Michigan. They are of the high grade Old Range type and when dry contain 60% iron. .26 tons of slag are made per ton of iron produced.

SPRING LAKE IRON COMPANY.

In 1879 the Spring Lake Iron Company was organized in Michigan with a capital stock of $30,000. A furnace was erected at Fruitport, Michigan. At this point direct connections by water can be had with Chicago, Milwaukee, and other distributing centers. The officers of the company are J. C. Ford, President and Treasurer, and Frank F. Bowles, Secretary.

The stack proper is 50′ high and 11′ in diameter at the bosh. The blast is heated by iron pipe stoves. The capacity of the furnace is about 75 tons of pig iron per 24 hours.

At present the plant is not in operation. This is in large measure due to the present dull condition of the pig iron market. In addition the furnace needs extensive alterations before further production can be carried out. These alterations and repairs will be made as soon as an improvement in the pig iron market conditions warrant.

STEVENSON CHARCOAL IRON COMPANY.

The Stevenson Charcoal Iron Company was organized on June 9, 1911, with a capital stock of $150,000.00. The plant is at Wells, Michigan and for transportation purposes is extremely well located, as it is on the Chicago and Northwestern; Chicago, Milwaukee and St. Paul; and Sault Ste. Marie Railroads. The officers of the company are Charles H. Schaffer, President; Grant T. Stevenson, Vice President; and J. R. VanEvera, Secretary and Treasurer.

The erection of the plant at that point was in order to utilize the vast quantities of charcoal that are being produced there daily by the Meshek Chemical Company. It is expected that the furnace, which is now in process of erection, will be completed so that it can go into blast about July 1, 1912. The stack proper is 60′ high and has a bosh 10′ in diameter. It will produce about 60 tons of pig iron per 24 hours. Connected to the furnace are two fire brick stoves. There is also at the plant the usual apparatus consisting of such things as a blowing engine, pumps, boilers, etc.

COKE FURNACES.

Of the coke blast furnaces in Michigan there are three in number, and all, strange as it may seem, are located within the bounds of Detroit. One controlled by the Detroit Furnace Company has rather a small tonnage and resembles to a great extent a typical charcoal furnace in that it uses pipe stoves, is hand filled, and is of small capacity.

The two furnaces of the Detroit Iron and Steel Company are located on Zug Island, are in every way modern, and as far as operative costs are concerned should make pig iron at nearly as low figures as any pig iron plant in the country.

It is very probable that there will be no further coke furnaces erected within the bounds of the State for a number of years; largely because there is no great iron consuming center other than Detroit, and it is very probable that for many years to come there will be no one portion in Michigan which will rise to such an industrial condition as to be a large and important pig iron consuming center.

DETROIT FURNACE COMPANY.

The Detroit Furnace Company was organized on April 1st, 1906 with $150,000.00 capital stock. Its officers are J. C. Clutts, President; J. K. Pollock, Vice President; and C. F. Fraser, Secretary and Treasurer. The furnace plant itself has been built and in operation off and on for over 40 years. It was formerly controlled by the Wayne Iron Company, and up to the time of its purchase by the Detroit Furnace Company charcoal was the fuel used. The present management have, however, run it with coke, and this furnace, together with the two of the Detroit Iron and Steel Company, comprise the three furnaces which use coke in the production of pig iron in Michigan.

The furnace itself is 62′ high and has a bosh diameter of 12′ 6″. The throat diameter is 7′ 4″ and the hearth diameter is 7′ 6″. The depth of the hearth is 7′ 8″. It has 7 twyeres, the blowpipe nozzle diameter of which is 3½″. The blast pressure ranges from 5 to 7 pounds, and about 7,000 cubic feet of air is blown into the furnace per minute. The stated capacity of the furnace is about 75 tons of pig iron per day, and approximately 2,500 pounds of beehive coke is consumed in producing a ton of pig iron. About 1,650 tons of slag is made per ton of pig. The furnace is hand filled.

Connected to the furnace are three U-pipe stoves wherein the blast is heated from 600° to 850° F. The blast is supplied by 1-500 H. P. Weimer vertical blowing engine. The boiler installation consists of 5 horizontal Brownell boilers of 150 H. P. each.

DETROIT IRON AND STEEL COMPANY.

The erection of the plant of the Detroit Iron and Steel Company was the first important endeavor to locate within the bounds of Michigan a modern and up-to-date blast furnace plant in which coke was to be used as the metallurgical fuel. The company had its origin on April 24, 1902. There has been an issuance of $750,000 of preferred stock and $750,000 of common stock. The officers of the company are D. R. Hanna, president; F. B. Richards, Vice President; R. L. Ireland, Vice President; C. W. Baird, Secretary and Treasurer; Max McMurray, General Manager; and P. J. Moran, Superintendent.

The plant is located on Zug Island and lies between the River Rouge and the Detroit River. Such a location enables ore to be unloaded directly at the furnace. It has direct connections with the Michigan Central; Detroit, Toledo and Ironton; Detroit and Toledo South Shore; Wabash; Pere Marquette; and Canadian Pacific Railroads. Connections to these last three are via. the Delray Connecting Railroad.

There are two stacks at the plant, one known as "A" furnace and the other known as "B" furnace. "A" furnace was built and put in blast about 1902, while "B" furnace was not erected and put in blast until July, 1910.

"A" furnace is 78′ high, 18′ 8″ at the bosh, 12′ 6″ at the throat and 13′ at the hearth. The depth of the hearth is 6′. It has 10 twyeres, the diameter of the blowpipe nozzle of which is 5″. This furnace produces a tonnage of approximately 300 tons of pig iron per day and in doing so consumes from 2,200—2,400 pounds of by-product coke per ton of iron. From 27,000 to 30,000 cubic feet of air is blown into the furnace per minute under a pressure of approximately 13 pounds. The blast is heated to a temperature of about 1,000° F. To do this there are 4 Garrett-Cromwell 2-pass brick stoves, each one of which is 83′ high and 20′ in diameter. The furnace was in continuous operation from the time of its erection until June, 1911, when it was taken off for repairs. At that time it had a 3/8″ shell with a 42″ brick lining. Since that time the stack has been entirely rebuilt and it has now a 3/4″ shell with a 12″ lining. The stack is water cooled above the mantle, however. In addition to the water spray, 6 rows of bosh plates are in use.

"B" furnace, which was put into blast for the first time in July, 1910, has a ¾″ shell with a 48″ brick lining. The stack proper is 80′ high. The diameter of the bosh is 18′ 6″, the diameter of the throat is 12′ 6″, the diameter of the hearth is 12′ 6″, and the depth of the hearth is 7′. The furnace makes approximately 325 tons of pig iron per 24 hours and in doing so consumes from 2,000 to 2,200 pounds of beehive coke per ton of pig. 32,000 cubic feet of air is blown into the furnace per minute at a pressure of about 13 pounds and at a heat varying from 1,100° to 1,200° F. There are 12 twyeres 5″ in diameter at the nozzle of the blowpipe. The furnace is equipped with four Nelson-McKee 2-pass brick stoves, each one of which is 85′ high and 12′ in diameter.

Both furnaces are skip filled, "B" with a steam hoist and "A" with an electric hoist. Attached to "A" furnace is 1 large dust catcher, while attached to "B" furnace is 1 large dust catcher and 1 Mullin gas washer.

The blast is furnished by 5 blowing engines. On "B" there are two Allis blowing engines, each one 84″ x 60″. They are both of the long cross head disconnected compound type. On "A" there are two high pressure and one low pressure engine of the long cross head type. These last were made by the Tod Blowing Engine Company. Altogether there are 13 boilers at the plant; 8 are on "A" and 5 are on "B," giving a total of 2,000 H. P. The 8 "A" boilers are of the Babcock and Wilcox type, and the 5 "B" boilers are of the Wicks vertical type. Electric power is furnished by 1 Bullock 300 K. W. generator and 3-Elell-Parker generators of 200 K. W. capacity each.

The casting of the pig iron is done both in sand and in a Uehling single strand pig casting machine. The length of the strand, c to c, is 140′. In the cast house there is one Brown pig breaker.

For the handling of the raw materials and especially for the unloading of the ore from the boats there have been installed two Wellman-Seaver unloaders, each one of which has a capacity of 200 tons per day. There is also one Brown hoist unloader, with a daily capacity of 300 tons. These unloaders remove the ore from the boats, transfer it to stock bins and do other miscellaneous work.

The ores used at the furnace are of the Old Range and Mesaba grades, with an average iron content of about 51½%. "A" furnace uses by-product coke obtained from the Solvay Process Company's plant which is located just across the river, and "B" furnace uses Connellsville beehive coke.

THE J. T. JONES' STEP PROCESS FOR THE METALLIZATION OF LOW GRADE IRON ORES.

BY ALBERT E. WHITE.[1]

At the present writing there is probably no more interesting experiment being carried on, than that which Mr. J. T. Jones is conducting at Republic, Michigan. The experiment proper consists in the endeavor to convert into a commercial product the vast quantities of low grade iron ores which are found on the Marquette, Menominee, Gogebic, Vermilion, and Mesaba Ranges; but especially those found on the Menominee and Marquette Ranges. Mr. Jones has been working on this experiment since September, 1908. He has spent vast sums of money in carrying out his ideas and in making such changes as became necessary from time to time and there is little doubt but what in a very few months the results of his work will be definitely known, and one can then be certain as to whether or not the metallization of low grade iron ores will prove to be a commercial success.

Before proceeding further it should be made clear that it will probably become true that the Jones process will not be applicable to all types of low grade iron ores found on the iron ranges, but only to those possessing certain definite characteristics. In spite of this narrowing of the proposition, there is little question but what his process is applicable to extremely large quantities of iron ore, and for that reason it is the writer's belief that the vast sums of money which have already been spent are altogether warrantable. This narrowing of the process is but following the common law of all ore-dressing operations, for in all work of this nature there is no one process or no one portion of a process which is applicable to all grades and types of ore.

Not since the early days when steel was made in this country in a Bessemer converter for the first time, at Wyandotte, Michigan, has an experiment been carried on containing such possibilities. There has never been an experiment carried on in the borders of this State which, if successful, will mean more to this State than the experiment which Mr. Jones is doing at Republic, and

[1] Instructor in Chemical Engineering University of Michigan.

which had its origin and the beginning of its development at Iron Mountain. It is a process and a scheme which is worthy of the kindest criticism and which is well worth being financially backed for the possibilities of financial returns which it possesses.

The experiment in brief is to take low grade iron ore and by bringing it into contact with the volatile matters of coal or wood and likewise the fixed carbon which is found in the coal or wood it is expected that the oxygen will be driven out of the iron oxide of the ore leaving the iron in the ore in a metallic condition without in any way fluxing or melting the iron or gangue found in the ore—and then by a process of magnetic concentration the iron will be freed from its gangue and there will be obtained as a result a product by all means fit for blast furnace use and possibly of such a high grade as to be acceptable for open hearth use.

It is true that Mr. Jones has met with considerable criticism with regard to the possibility of success for his proposition. Most of this criticism has come from men who have vast sums of money invested in blast furnaces and other modern steel making appliances and who regard his process as alien to their best interests rather than as a supplement to the present methods of iron and steel making now in vogue. Some have even gone so far as to condemn his proposition after but a very hasty and superficial glance at its possibilities and little if any weight should be given to such condemnation.

On the other hand there are many men who are warm supporters of Mr. Jones' idea. They realize the great hesitancy with which new schemes are first received. They further realize that at the start there are many factors which have to be met before any new proposition is worked out to a financial operating success.

Of course the crucial crux to the entire process lies in the amount of fuel which it will be necessary to consume in metallizing one ton of product. In an operation which Mr. Jones carried out last winter at Iron Mountain similar to the present one in principle although with a different type of roaster, 85 pounds of fuel was consumed per 100 pounds of product metalized. The inventor was taken sick and for a short period the writer handled the experiment and by judicial and careful work he was able to bring the fuel consumption down to 52 pounds of fuel per 100 pounds of product metallized. The writer, however, is of the firm belief that it will require but 40 pounds of fuel per hundred pounds of ore to bring about satisfactory metallization. In this figure he is assuming the use of fixed carbon alone. Theoretically it requires but about 26% of soft coal to do the work necessary in metallizing, and with an allowance of 40% there is therefore 15% excess. Of course there is no question but what the volatile matters in coal will metallize ore providing you keep the ore in contact with the volatile gases for a sufficiently long period. Such a thing as this is extremely difficult to do on a commercial scale for the volatile gases always have a tendency to escape and at the present time there is no mechanical appliance known that is capable of keeping the gases and a product such as low grade iron ore in contact for a period sufficiently long to allow of the complete metallization of the ore. It is because of the difficulty of metallizing the hydrocarbons that the writer has based his calculations on the fixed carbon found in coal.

There is a further possibility of making use of the large quantities of waste wood that are found in the vicinities of the low grade ore deposits for the metallurgical fuel to be used in the reduction. Such a possibility as this is worth considering on a small scale. It cannot assume large proportions, however, because of the fact that the supply of wood in the State of Michigan is rapidly decreasing and it will be but a question of time before the entire supply is practically consumed. For that reason it is only just that the process when looked at from the larger aspect should seek its fuel from coal.

Mr. J. T. Jones was led to the idea of conceiving the process for the utilization of the low grade iron ores because of the immense tonnages which are found in the Lake Superior region and because of the immense possibilities which a successful method for the treatment of the ores possesses. Before arriving at a scheme of metallizing he threw aside practically all other methods capable of containing possibilities for the recovery of the values found in the low grade ores. It seems to the writer that for the most part he was quite justified in taking the attitude which he did, for he was chiefly interested in the ores which were found in the Menominee and Marquette districts. These ores are quite hard and recent experiment has shown that they are not treatable in accordance with the modern methods of wet gravity ore dressing or milling.

The inventor at first felt, that with the proper tools he could reduce the iron found in the low grade ores to a metallic sponge, keeping the temperature throughout this portion in the operation at a point below the melting point of both the iron and of the slag forming constituents. When in a metallized condition the product was then to be heated to a temperature sufficiently high to flux the gangue—gangue which for the most part was silica and which was to be fluxed with iron oxide—but at a temperature not hot enough to melt the iron. It was then to be the endeavor to squeeze out the liquid impurities from the pasty iron. After many trials, however, it was learned that there was no known means of getting a fire brick lining which would stand up under the fluxing action of the iron oxide present in the product. To carry out this idea Mr. Jones erected near his home at Iron Mountain a large kiln 120 feet long and 8 feet in internal diameter which was supplemented with such necessary accessories as crushers, crushing rolls, elevators, screens, etc. His idea at that time was to put the ore into the kiln at one end and have it come out at the discharge end in such a condition that the slag would be liquid and the metallized metal would be pasty, capable of immediate working into commercial muck bar. The difficulty with this scheme as stated above was the fact that the lining of the kiln would not withstand the fluxing action of the iron oxide. All types and kinds of fire brick were used, including such kinds as magnesite brick, chrome brick, silica brick, fire clay brick, etc., but to no avail.

His next idea was to keep the temperatures in the kiln down to such a point as would metallize the iron ore present, but which in no way would result in a melting of either the ore or the gangue. At almost the first attempt Mr. Jones succeeded in getting the type of product which he wished: a product wherein all the iron oxide present in the low grade ore was reduced to metallic iron. His difficulty here was the fact that there was too high a consumption of fuel and the formation of a ring in the tube caused continuous operation to be an impossibility.

In order to overcome the first difficulty Mr. Jones conceived the idea of allowing the volatile hydrocarbon gases in the bituminous coal to do the work. Such action, he felt, would result in a reduction of the iron oxide to a spongy metallic iron. It is from this step that the process called "metallizing" has derived its name. He had been able to carry out this idea in a crucible test, for without any difficulty whatever he had converted the iron in an iron ore to a metallic sponge and the bituminous coal from which he had derived the necessary hydrocarbons was converted into coke.

His great claim for the commercial success of the process lay in the fact that while he was converting the iron in iron ore to a metal he was, at the same time, producing a merchantable coke which, because of its value, would, in itself, more than pay for this particular step in the process.

So far Mr. Jones has had considerable difficulty in metallizing in his long tube by means of the volatile hydrocarbons. In fact one can state that as yet he has never succeeded in metallizing on a continuous commercial scale by means of the volatile hydrocarbons. Mr. Jones himself is aware of this difficulty and initially for the purpose of overcoming it, he inserted a charging door in his kiln two-thirds of the distance in from the feed end. At that point he inserted bituminous coal. His idea was to first allow the ore to become hot by means of contact with the escaping gases and through the combustion of a small quantity of fuel which he fed in with the ore, and after the ore had reached the necessary heat—which may be expressed as dull yellow because of the color of the ore—he added to it the bituminous coal which would furnish the hydrocarbons necessary to carry out the reduction of the iron in the iron ore to a metallic sponge. This step in the process was to be accompanied by the production of coke, for it was the endeavor to have the heat sufficiently great to free the coal of its volatile matter but not great enough to burn or consume the coke made after the expulsion of the volatile matter from the coal.

In carrying out this idea, two difficulties were encountered. In the first place the chemical and heat action at the point where the coal was fed into the tube was so great as to cause a superabundance of heat at this point. This caused melting of the gangue constituents of the ore and likewise a certain quantity of the iron in the iron ore was made metallic at this point. This caused it to become pasty. These conditions caused the materials to cling to the sides of the kiln in this vicinity and within 23 hours after this type of charging was resorted to, further use of the tube had to be abandoned until the ring was cleared away. The second difficulty was the trouble encountered in getting the coal which was charged through the side door underneath the ore burden. It was impossible to revolve the kiln faster than one revolution in 20 minutes. The kiln was fed with ore varying in sizes of from 2″ pieces to as small as dust. The larger pieces went through the kiln at a much faster rate than the smaller pieces did. To secure complete metallization of the entire product, it was necessary to adjust the speed of the kiln to suit the larger pieces of ore. For that reason the slow speed had to be adopted. Because of the slow speed the ore as it passed down through the kiln slid rather than showered, and because of this sliding action it was impossible to get the coal which was fed through the side door underneath the ore burden. For that reason the most of the possibilities that lay in metallizing through the use of the volatile hydrocarbons could not be utilized.

As a result, it was true that in practically all of the long runs which were made at Iron Mountain, the fixed carbon in the coal and not the volatile hydrocarbons was the agent which did the metallizing.

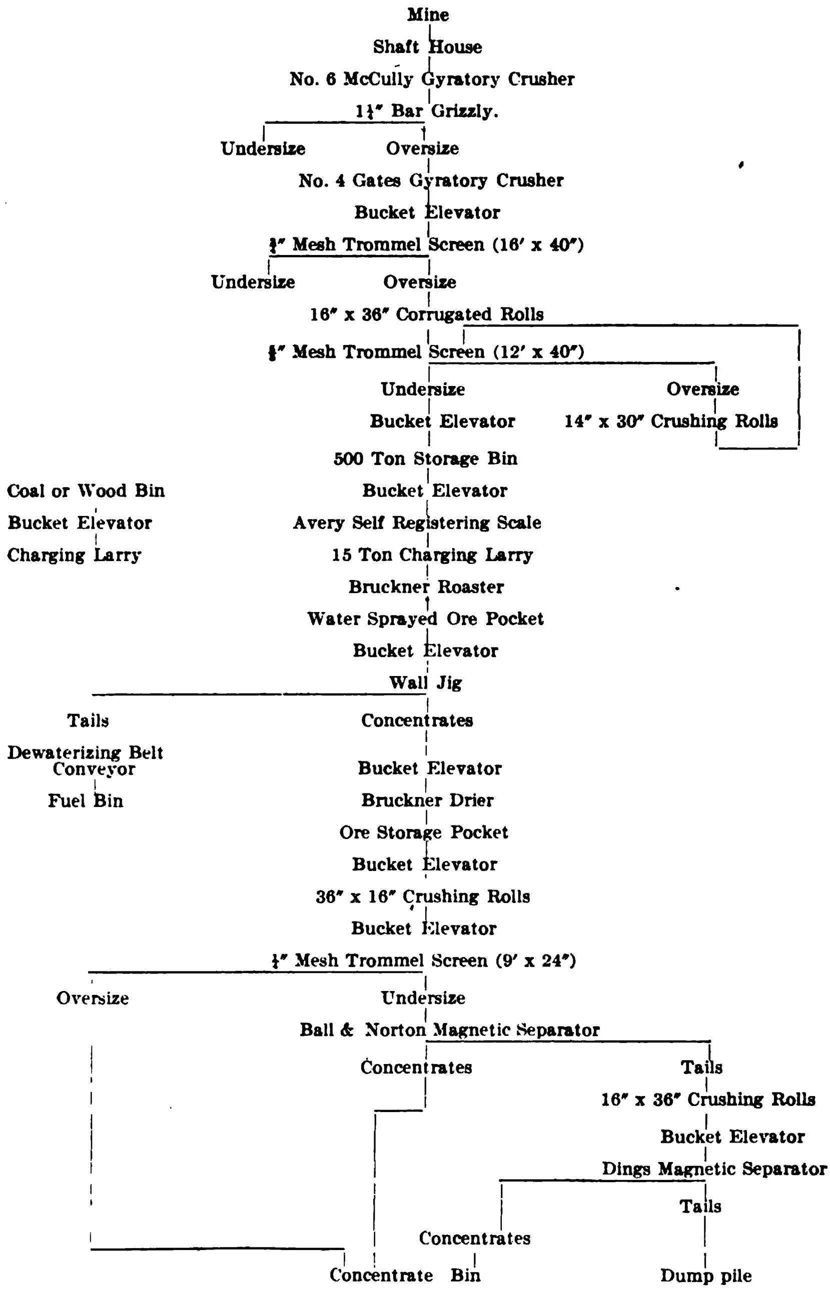
Mr. Jones appreciates this difficulty. In the early part of his experiments he endeavored to put lifters inside the tube. The lifters did not last, however, because the two kinds which he used were not adapted for the idea; the first one being a fire brick which was mechanically too weak to stand up and the other a concrete one which was not adaptable to withstanding heat.

In order to meet this issue more effectively Mr. Jones began, last spring, the erection of a metallizing plant at Republic, Michigan. He located the plant at the shaft head of the Kloman Mine for it is from this particular mine that the ore to be treated will be obtained. Mr. Jones has met with considerable criticism for utilizing this ore in his metallizing experiments, as it is claimed that it is the ore of ores on the Menominee Range most adaptable for the process laid forth. There is no question but what this ore is of a type which can be treated successfully in accordance with the proposed process, if any ore can be so treated. It appeals to the writer as though such criticisms are somewhat unjust because there is no question but what Mr. Jones has enough available ore in this one property to warrant the entire expense to which he has been placed if his proposition works out successfully and a proposition ought to be developed along lines most favorable for its advancement.

At the present writing it is the intention to mine the ore in the Kloman property according to the Glory Hole system made use of so commonly in the western part of our country, especially in the mining of our low grade copper ores. The ore will be hoisted to the surface and crushed in a No. 6 McCulley Gyratory Crusher. It will then be sized on a 1½ inch bar grizzly and the oversize will be again crushed on a No. 4 Gates Gyratory Crusher. The whole product will then pass through rolls and screens until it is broken down to sizes ⅝ of an inch in diameter or smaller. The product will then be placed in Bruckner roasters, fifteen tons at a time, for the purpose of metallizing. These roasters are arranged in series of two. One is metallizing the ore while the other is having the ore which is present in it heated up by the passage through it of the waste gases from the first roaster. After the product in the initial roaster is metallized the ore is then dumped into a water-sprayed pocket. Fuel is then added to the second roaster, likewise ore is added to the first roaster. Metallizing then takes place in the second roaster with the passage of the waste gases through the first roaster for the purpose of heating up the ore therein. The metallized ore from the pocket is passed to a jig for the purpose of removing any good merchantable coke which may be present. The concentrates are then carried to a Bruckner drier and from there are crushed to a proper size and then magnetically separated; with a final concentrate of such a grade as can be used in a blast furnace as an ore or else as a product for open hearth use.

The detailed flow sheet of this process is as follows:

FLOW SHEET OF THE JONES' STEP PROCESS FOR METALLIZING LOW GRADE IRON ORES.



The Brunkner roasters themselves, around which centers the entire success or failure of the proposition, are of a type so commonly made use of in the ore dressing operations of non-ferrous metals. Each one is 18′ 6″ long and 8′ 8″ in internal diameter. They will require 12 H. P. to start and but 5 H. P. when in operation. It is expected that each one will hold fifteen tons of ore at a charge, and it is hoped that but four hours will be required for the metallizing operation; two of which will be consumed in heating up and two in the reduction or metallization. By having them placed in series of two and by having the waste gases from one pass into the other, it is expected that from the two roasters a charge of fifteen tons of ore will be available every two hours. The roasters themselves are equipped with oil burners for the purpose of giving the supplementary initial heat. Charges of coal will be put into the roasters at the proper time for the purpose of completing the reduction of the ore. The roasters have a 9-inch lining of fire brick and at definite portions throughout the inside shell of the roaster there are placed fire brick projections which will serve as lifters for the purpose, if possible, of getting the coal underneath the ore in order that the escape of the volatile gases may have an opportunity to come into as close contact with the ore as possible. The tube itself will revolve at varying speeds depending upon conditions. It has a variance of from one revolution in forty minutes to ten revolutions per minute.

The entire metallizing and concentrating plant is electrically driven throughout. For this reason it has the following motors installed:

1 75 H. P. A. C. induction motor. This for the No. 6 and No. 4 crushers, all the elevators in the crushing plant, and in fact everything up to the Avery scale.

1 20 H. P. Variable speed reversible Western Electric motor. This for one tube and for ore elevator to Avery scale.

1 20 H. P. Variable speed reversible Western Electric motor. This for one tube and for driving the ore charging larry.

1 20 H. P. Variable speed reversible Western Electric motor. This for drier and for the coal-charging larry.

1 5 H. P. A. C. induction motor. This for coal hoist.

1 40 H. P. A. C. induction motor. This for separating plant.

1 6 H. P. D. C. generator. This to be driven by the 40 H. P. motor for the purpose of generating D. C. for the magnetic separators.

1 5 H. P. A. C. induction motor. This for a No. 2½ centrifugal pump.

To carry out the housing of this experiment it has been necessary to erect a set of completely new buildings. These are altogether of the reenforced concrete type. Three large buildings have been constructed, one of which is known as the Generator Building, another as the Boiler House and Machine Shop Building, and the third as the Mill. The first of these, or the Generator Building, is 40 feet long and 30 feet wide. It consists of but one story and is 11 feet high. In it is 1-200 H. P. Corliss Engine and 1-150 K. W. Western Electric A. C. Generator, furnishing 440 volts. This generator is equipped with an excitor, switch board, rheostat, and the other paraphernalia which go to make up an electric station.

The Boiler House and Machine Shop is all under one roof, in a building 125 feet long, 18 feet wide and 8 feet high. The Boiler House proper is 40 feet long and 18 feet wide; and the Machine Shop, containing as it does the air-compressors and hoists, is 60 feet long and 18 feet wide. The Boiler House contains 1-250 H. P. Continental water tube boiler. There is also 1-15 H. P. upright boiler and 1 exhaust water heater. In the Machine Shop section of the house is found one ten drill Ingersoll-Sargeant Compressor, one four drill compressor of the same type, one Webster-Camp & Lane five foot drum 2nd motion hoist, one 20 inch lathe, one drill press, and one shaper.

The Boiler and Generator Houses are placed at a distance of about 400 feet from the Mill. The Mill is directly at the head of the shaft. This arrangement will be noted from an examination of the accompanying photograph. The general arrangement of the layout in the Mill can also be noted from an examination of the flow sheet of the process found in this chapter.

At the present time there is a great difference of opinion as to just what the cost of making iron from metallized ore will be. If it is possible to get a product containing approximately 95% of iron, and from 4% to 5% of gangue with but about .05% sulphur there will be no question but what this product could be successfully used in an open-hearth furnace. It is true that there might be some objection to its use there on the claim of its fineness, but because of the general nature of the Kloman ore it will probably be true that such an objection will not hold.

The main trouble will probably be with its quality. It will probably be certain that it will be impossible to obtain a product containing more than 85% of iron, and such a product, because of the high percentage of gangue necessarily present, would find no

PLANT OF KLOMAN MINING COMPANY AT REPUBLIC, MICHIGAN.

ready sale for open-hearth use. There is another great objection, which as yet has not been emphasized, and that is the tendency which this material possesses to absorb sulphur from the surrounding coal with which it is in contact. It will very probably be true that a final product will be secured from the metallizing plant containing not less than from .1% to .2% sulphur. For this particular reason it will probably be true that the natural outlet for the use of this material will be in a blast furnace. For that reason the fears of so many people that the installation of the Jones process for the utilization of the low grade iron ores will completely revolutionize the present practice of making steel is nothing more nor less than a visionary bubble.

ESTIMATE OF COST OF METALLIZING AND SMELTING LOW GRADE KLOMAN IRON ORE.

Mining	2.66 tons at $0.30	$0.798
Crushing	2.66 tons at .08	.213
Screening	2.66 tons at .05	.130
Concentrating	2.66 tons at .08	.213
Conveying	2.66 tons at .10	.266
Jigging	2.66 tons at .05	.133
Fuel	....	3.180
Repairs	2.66 tons at .10	.266
Tailing disposal	1.66 tons at .08	.133
Freight	1.00 ton at 1.50	1.500
Total cost at Chicago	....	$6.832
Cost per unit at Chicago	....	.08

SMELTING.

Ore	1.18 tons at $6.83	$8.06
Stone	.50 tons at 1.00	.50
Coke	1000 lbs. at 4.50	2.25
Labor and repairs	....	1.25
Cost per ton of pig iron at Chicago	....	$12.06

ANALYSIS.

	Crude ore per cent.	Concentrates per cent.
Iron	40	85
Silica	35	12.5
Other gangue	7	2.5
Moisture	1	....

In arriving at this estimate the natural ore is credited with containing but 1% of moisture and 42% of gangue of which 35% is silica. As we lose 20% of the iron present in our process of magnetic concentration it becomes true that it will be necessary to use 2.66 tons of crude ore in order to get a concentrate containing 85% of iron.

It has been the endeavor to make the crushing, screening, concentrating, conveying, jigging, and repair costs full high and there is little doubt in the writer's mind but what the actual operating costs of certain of these items will be materially reduced when operating on a large scale.

The smelting center adopted has been Chicago. The cost of the metallized ore at this point will prove to be approximately $.08 a unit. It will roughly require ½ a ton of limestone to do the necessary fluxing. The amount of coke that would be required to smelt this product is at present a matter of mere guess work. Allowing .8 of a ton of coke for a ton of silica as our basis for the amount of coke required to flux out the silica and 300 pounds of coke for a ton of metal as our basis for melting the metallic iron present in the product it will be noted that but approximately 500 pounds of coke are required per ton of pig iron. 1,000 pounds have been allowed and the doubling of the requirement seems more than ample.

Adding up all of the various items it can be observed that it will cost approximately $12.00 to make a ton of pig iron out of many of Michigan's vast number of low grade iron ore deposits. It is believed that this figure allows ample allowance for any contingencies that may come up. It does not take into account the fact that there is a possibility of making a soluble coke as a by-product. It does not take into account the fact that there is a possibility that a product of high enough grade for open hearth use may be made. It has put, colloquially speaking, the worst foot forward and the figures show that it is a proposition worth developing.

We will all watch with great interest the growth of the ideas which Mr. J. T. Jones has clung to so tenaciously the past few years and we sincerely trust that within the next six months he will be able to break down the present bars of skepticism by having at hand actual proof concerning what can be done with regard to the metallization of certain types of Michigan's low grade iron ores.

MICHIGAN COAL.[1]

BY R. A. SMITH.

CONTENTS.

CHAPTER I.

OCCURRENCE AND EXTENT OF COAL AREAS.

Occurrence. Coal occurs in beds associated with shale, fire clay, black band ore, limestone, and to a less extent with sandstone. The latter more often increase in abundance at the expense of the coal. This is a most significant fact. The coal may be in a single bed or in several, separated by beds of shale or so-called slate, fire clay, etc. These laminae of shale may be no wider than a knife blade or may be many feet thick. Often thin veins of shale interbedded with the coals may thicken so that a single vein of coal becomes several distinct beds.

[1]Mainly an abstract of A. C. Lane's treatise in Vol. VIII, 1902, Michigan Geological Survey, with addition of statistical and other data.

The upper coals of Michigan are very apt to show this phenomenon. This makes it very hard to correlate them because corresponding veins vary in level more or less with the thickening and thinning of the shale laminae. Sometimes these, though often very persistent even when thin and knife-like, disappear and several beds, distinctly separated at one place, become a single thick one at another. In other cases, the content of clayey matter increases gradually so that a coal vein grades vertically and laterally through cannel coal, bone coal to black shale. It is these shales with their gradation phases which many drillers confuse with true coal and thus are led to report great thicknesses of coal where little or even none exists. The shales, usually black, form in most cases, the roof of the coal seams. Shale forms an impervious roof, but is likely to be weak, and thus need a good deal of timbering, if close to the rock surface. An impervious roof is all important in Michigan as water is so abundant. At best, Michigan coal mines are much wetter than those of Ohio and Indiana, but the water comes chiefly from the coal—the foot wall. The cost of getting rid of the water is one of the chief factors that permits Ohio operators, in dull times, to lay down at a small profit their excess coal at the very tipples of Michigan mines at prices ruinous to Michigan operators. A sandstone roof is a very wet roof as in the case of the Gage No. 3 and no mine is known to have a real limestone roof. The Verne coals, however, are apt to have considerable limestone associated with them.

Extent. Coal beds in most districts are usually continuous for considerable distances and the existence of a coal bed can be predicted with some degree of certainty for some distance from known occurrences as in Pennsylvania and Ohio. *In Michigan, such conditions do not obtain. The beds thicken and thin, divide or unite, and pinch out so rapidly, or are cut out by sandstone beds or by erosion so often, that the finding of a thick bed at one place forms no proof that the same bed or other beds may be found a few hundred feet away. On the other hand, the absence of coal at a particular spot does not preclude the possibility of finding workable coal at astonishingly short distances away.* At the Corunna Mine, a 4 ft. vein of coal was found and 200 feet away not a trace was discovered, the bed having been cut out by sandstone layers. This variation in thickness, extent, and number of veins demands more complete prospecting to determine the extent and value of a coal bed after having found it, than it would, were the beds more continuous and more uniform in thickness and character.

The explanation of the great variation in the Michigan deposits in contrast to those of Pennsylvania and other coal states, lies in the difference in the relative conditions under which the coals of the two areas were formed. After the Maxville limestone was laid down in the more or less inclosed Michigan sea, the region was elevated above water bringing the Maxville within the reach of the erosive agents which cut it up into a network of river valleys. The Maxville on the southeast was wholly removed from Jackson nearly to Tuscola Co., the coal measures lying directly on the Marshall. In late Maxville time, the topography on the eastern side of the basin may have somewhat resembled that of eastern Kentucky. When the region was depressed these valleys became bays, lagoons, and estuaries possibly resembling the conditions of a drowned coast. It was in these depressions that vegetable material collected. Near Jackson, the Maxville forms the hills with the coal measures lying in between and flanking them. The Jackson trough was hardly more than 150 yds. wide and a few hundred feet long. From this it may readily be seen that in the southern and eastern parts of the basin, expecially, few if any of the coal veins could be continuous for any great distance.

CHAPTER II.

THE MICHIGAN COAL BASIN.

The Michigan coal basin, or the northern region of the Interior Basin, as it is now called, is the only one that lies in the Great Lakes drainage area. It comprises some 11,500 square miles and occupies almost the exact geographical centre of the Lower Peninsula. It is most ideally located, being in the heart of a thickly populated and rapidly growing manufacturing district. Not only this, but numerous railroads, Saginaw Bay and River, which penetrate to the very heart of the field, and the system of Great Lakes offer a means of distribution unequaled anywhere. Indeed, it is largely due to the rapid growth of manufacturing cities along the lower Great Lakes and the easy access to their markets that Michigan, with thin and variable veins of low grade coal and wet mines, owed the sudden and wonderful development of her coal industry between 1897 and 1908. No where in the history of the coal industry of the United States is there a like parallel in growth, unless we except the recent one of the Triassic basins of Virginia.

The Coal Basin may be roughly outlined by drawing line (See Fig. 12) from Jackson, to the northeast of Bellevue, Eaton Co., through Lake Odessa, Ionia Co., Lowell and Rockford, Kent Co., Newaygo and Woodville, Newaygo Co., Big Rapids, Mecosta Co., Evart, Osceola Co., Temple, Clare Co., Beaver Lake and West Branch, Ogemaw Co., Omer, Arenac Co., along the south side of the lower course of Rifle River, across Saginaw Bay to the north and east of Sebewaing, Huron Co., through Caro, Tuscola Co., Belsay, Genesee Co., through the northwest corner of Oakland county, to Lakeland, Livingston county, thence to Chelsea, Washtenaw county, and through Grass Lake back to Jackson. Some of the places, as Bellevue, Lowell, Big Rapids and Caro are just outside of the limits of the coal basin, while Newaygo, West Branch, Sebewaing, and Jackson are just inside. The outline so drawn does not represent the irregularities or the outliers of the borders. The data, except in certain localities on the eastern side, is too meagre to attempt anything more than an approximate representation of the outline of field. Coal formation undoubtedly exists outside of the area enclosed above and is lacking in other places inside.

Naturally the border of the coal basin is not so regular as is indicated on the map, but is more or less continuous, depending in a great measure upon the amount of erosion after the beds were laid down. It must be kept in mind that the coal measures were elevated above water and, have been exposed to erosive agents

Fig. 12. Map of the Michigan Coal Basin. Portions colored black represent the areas of proven coal of commercial importance.

for an enormous length of time. Streams cut deep valleys in them and then the ice invasion planed and more or less leveled off these irregularities. Many of the valleys were grooved deeper while others were filled up by glacial debris. One of the results of the successive glaciations was the covering up of the rock surface by glacial material varying from a thin screen of almost nothing to a blanket 600 or more feet thick. It is this blanket that makes the line of demarkation between the various formations most uncertain in many instances. Where the screen is thin, the bed rock is exposed in places as along streams, etc., or wells penetrate it. Drillings for coal, brines, oil and gas, and water in Saginaw Valley, especially, have given a wealth of information. Thus the eastern and southeastern border of the basin is fairly well determined from the numerous well records and outcrops, but, on the western, northwestern and northern borders, the drift is so deep that outcrops do not occur and wells rarely reach bed rock. Here the border can only be guessed at from the few and perfect records of wells that reach bed-rock, from the occurrence of coal in the drift, or from inferred field relations with other formations.

The area outlined on the map occupies almost the exact geographical and the commercial center of the State. Commonly known as the Coal Basin it is the only formation in Michigan in which the beds do not dip toward and occur deeper at the center than at the margin. (See Fig. No. 12.) Apparently all other formations are true basins though shallow. The fact that the coal formations were laid down in a dissected or much cut up region probably has considerable bearing on the explanation.

At the base of the coal measures lies the Parma sandstone. Though not always present or recognizable, at some distance beneath this formation comes a sandstone, the Napoleon or Upper Marshall, which can be followed by outcrops or by well drillings, all the way from the sandstone bluffs of Huron county into Sanilac county and southwest past Island Lake into Hillsdale county, and thence in wells on to Grand Haven, Muskegon, and Ludington. Since it is full of water, it has been tapped many times for fresh water near its margin, and for salt and bromine waters toward the center. Such wells make it recognizable also at Tawas and to the northwest, thus for nearly two-thirds of the basin it has been followed fairly continuously.

The outcrop, or what would be an outcrop, were the glacial deposits stripped off, would be usually higher then the coal basin itself, thus it really makes a rim about the latter.* Below the Napoleon or outside it, no coal in commercial quantity has been or is ever likely to be found.

Many instances have occurred in Michigan where men have spent their time and money drilling for coal outside the coal basin.

* Lane, Vol. VIII, pt. II, p. 26.

Often, the Devonian black shales have led drillers on a proverbial wild goose chase as far as the find of coal is concerned.

Early geologists supposed the coal beds of Michigan and Ohio to have been originally continuous and were then folded gently so that erosive agents removed the coal from the arches. Were this so, one could expect to find outliers of coal which had escaped destruction. The[2] evidence is almost absolutely conclusive that these fields were never connected, thus exploration outside the coal basin in the hope of finding an outlier of coal is bound to be fruitless.

Thickness of Coal Measures. As noted on previous pages, the dip of the coal formations does not conform to the lower formations. The term basin referring to shape does not mean so much, when applied to the Coal Measures as when applied to the underlying formations. The Upper Marshall sandstone has been tapped at various places within the basin at depths varying from a few hundred to more than 1,200 ft. The Michigan series lies just above, except where eroded, so that, calculating from the average thickness of this series, the Coal Measures should come at a 1,000 feet or more in the deepest drillings. On the contrary, nothing like the Coal Measures proper has ever been found much deeper than 800 ft.

Evidently the strata of the latter are more nearly horizontal than the Marshall and other underlying formations, which must have been slightly depressed in the centre before the coal formation was laid down. Near the margin, the coal formation becomes very thin from erosion, but near the centre there are known local thicknesses of more than 600 feet. Thus, whatever unfavorable factors may affect coal mining in Michigan, excessive depth probably will never be one of them.

Since the coal formation was laid down on the much eroded surface of the Maxville limestone, it is natural that we find the coal lying *"In the minor undulations, independent of the general curve of the whole formation and the basin which it forms."* These undulations are called by miners "hills" or "rises" and "valleys" or "swamps." The term "pockety" is applied to such occurrences. It is a practical rule of miners that the coal rises and falls in undulations.

In the lower part of the undulations, the coal is thicker and thins to the rise. Nearly every mine presents an almost invariable series of such occurrences. (See Sebewaing cross section, Fig. 3, Lane, Vol. VIII, pt. 2, p. 31.) This tends to make the deposits

[2]See Lane Vol. VIII, pt. II, p. 27.

trough shaped. The latter phenomena are also common to other coal fields as noted by Bain & Keyes of Iowa and Orton of Ohio.

The lower and thicker parts of the troughs of coal are very apt to be capped by a smaller coal seam known as a rider. Dr. A. C. Lane noted this phenomenon in Michigan coal troughs but was not sure of its wide application to Michigan deposits. Later studies by him and Mr. W. F. Cooper[3] seem to warrant a much more general application of the principle. In Bay county, riders seem to be almost universal. Sometimes these riders are locally thick enough to mine, but, they would require even more careful exploration than the coal troughs to determine their economic value.

Bain especially developed the law of coal riders. His explanation was that the lower coal, which, if 5 ft. thick, represents 50 to 60 ft. or more of peaty material, in settling and compacting made a shallow basin above in which the rider formed. Thus riders are not considered unfavorable signs for more coal below.

Dr. Lane divided the coal horizons into seven and Cooper in Bay county report added seven more, making fourteen in all. The full series are: Reese Coal? Unionville? Salzburg? Rider, Salzburg Coal, Upper Rider, Upper Verne, Lower Verne Rider, Lower Verne Coal, Middle Rider, Saginaw Coal, Lower Rider, Lower Coal, Bangor Coal, and Bangor Rider. Since the whole formation varies so rapidly in the thickness and nature of its beds, probably some horizons may be synonymous. All of the beds occur within a vertical distance of 400 feet and, since a seam may vary 20 ft. or more in elevation in a couple of hundred feet, and also vary greatly in thickness, little value should be placed on such a series of horizons. Doubtless ten or twelve of the above are distinct horizons.

The Bangor Coal and Rider form the lowermost veins, the mother seam being from 350 to nearly 400 feet below surface in Bay county. The rider is often 50 to 60 ft. above. Dr. Lane thinks that these coals may be equivalent in part to his Lower Coals, the next horizons above. Not much is known of them but, from some of the deeper drill holes, the Bangor Coal appears to be of sufficient thickness for working, especially if it can be mined with the underlying fire clay. The roof is black shale.

The Lower Coal and Rider come next in order above and usually appear in the horizon lying between 240 and 325 ft. The mother seam has an observed maximum thickness of three feet. The usual foot and roof shales are apparently quite variable in thickness. This seam appears to be of probable commercial value.

[3]Bay County Report 1905, p. 190.

The Saginaw Coal, one of the thickest and most extensive seams in the state, is probably the best vein in quality, though its coal is non-coking. Its thickness is often more than 3 feet and it forms the base of most of the mining in Saginaw county. The superior St. Charles coals come from this horizon. The Middle or Saginaw Rider also seems to be a seam of considerable thickness and possibly the East Saginaw mines have their shafts in this coal.

The Lower Verne is at some places so closely associated with the Upper Verne that the two could be worked as one seam. In other places they are 40 feet or more apart. This vein is of much lower grade than the Upper, for it has much ash and sulphur. The roof is usually none too good. The general average in thickness for the coal areas is somewhat near two feet and it would be the base of more extensive mining operations, were the coal of better grade.

The Upper Verne stands in the same relation to Bay county mining as the Saginaw Coal does to Saginaw county. Thicknesses above three and four feet are often found. As noted above, it is of much better grade than the Lower Verne, being much freer from ash and sulphur. It has another good quality in not having a high water content like the Saginaw. The fixed carbon is rather low, (see table of analyses, Chap. III) and the volatile matter high. This coal leans toward the coking and gas making coals, but trouble in handling or adapting it to the producers in use, and the rather poor quality of the coke have prevented any use of the coal for such purposes. According to analyses the Verne coals appear to be related to the lignite coals. Probably they were never subjected to deep burial, so still resemble the woody end of the coal family.

As so-called fire clay is a common foot wall, it may, in the future, give added value to the seams, so that the thinner ones can be profitably worked. Plans for using the fire clay and shale of an abandoned mine in Bay county are reported as already under way. The usual black shales form the roof.

The Upper Rider is often associated with the mother seam. It's thickness of 12-20 inches warrants the supposition that locally it may be workable. "Washouts" often cut out this coal, and the roof is apt to be thin, weak, or wet, so care must be taken in proving up before beginning mining operations.

The Salzburg Coal and its rider are very often removed by erosion. It is only locally that the bed-rock surface is high enough to contain these horizons. As the thickness of the mother seam is more than two feet, and in some cases over three it has possibilities for profitable mining but the nearness to the rock surface makes in general unfavorable mining conditions.

The Reese and Unionville coal seams are little represented in drillings. Lying so high in the coal measures, erosion would have removed them in large part if they really ever existed.

Variation in Michigan Coal Measures. Without question, no bed of coal was ever continuous over the basin. Records at Alma, St. Louis, St. Johns, Ithaca show little or no coal. These, however, do not form conclusive evidence of the non-continuous character of the beds, as we know sandstone beds often replace the beds, showing that the coal was cut out after it was formed. A more significant fact lies in the occurrence of beds at all sorts of elevations above the Napoleon from 163 to 1,005 feet as at Sebewaing and Midland respectively. Deep wells near the center of the basin show black shales and bituminous limestones at the same horizons at which coal occurs at the margins. The beds are often of such local extent that it is never safe to attempt any exploitation of coal deposits without a proving of the area by thorough drilling, and even this is not always reliable. Too often a coal bed gives way to black shale horizontally and vertically or its place may be taken by sandstone. Cannel coal and bone coal are often observed as gradations from coal to black shale. The never ending alternation of sandstone and shale exists in every variety and the existence of coal even in the midst of a productive area cannot be predicted with any degree of certainty. Iowa as well as other coal fields seem to have similar, though not so extreme conditions of variation.

Areas Favorable for Coal Occurrence. A greater abundance of coal is found nearer the margin of the main coal basin, the coal beds diverging and thinning out with (increasing) depth and the coming in of the lower coals. The rest of the series thickens toward the center but, in other directions, irregular and sudden thinning is often the rule.

Jackson and Sebewaing are at the every edge of the basin. Though Williamston, Saginaw and Corunna are nearer the center, the basal sandstones are but little over 400 ft. below surface, so that they are not in the deeper parts of the basin.

A greater abundance of coal nearer the margin is to be expected. The areas most favorable for the growth of vegetable material is along the coasts, in lagoons, etc. Obviously, the region toward the center of the basin was more likely to be open sea and could hardly have other deposits than muds and sands. One must remember that the land surface upon which the coal deposits were laid down was considerably cut up by erosion.

Dr. Lane thinks that the southeastern part of the basin may have been not unlike a drowned coast with all the attendant features of lagoon, estuary, drowned valley, etc. Around Jackson, the evidence points to such a conclusion for the Maxville limestone tops the hills, between which, and flanking them, lie the coal measures. The extreme "pockety" nature of the coal deposits around Owosso and Corunna seem to be even more suggestive of such conditions.

CHAPTER III.

TESTS AND ANALYSES OF MICHIGAN COALS.

Tests and analyses of the earlier mined coals of Jackson, Corunna and Grand Ledge showed them to be of a decidedly low grade. They were as a rule light and friable, resulting in much slack or waste coal, high in ash, moisture, volatile combustible matter, and sulphur, and low in fixed carbon. The amount of fixed carbon was often only 40% and rarely over 45% with 2% to 3½% and more of sulphur and often over 10% of ash present. Then too the coals in burning would tend to run together on the grate, making them difficult of handling. Special grates have since been devised for such coals.

These early tests and analyses gave the general impression that all Michigan coal was alike and of very inferior grade. Thus in the commercial world Michigan coal has had a black eye which has been hard to remove.

Michigan coals vary greatly. The above mentioned coals are high in sulphur, those of the Saginaw seams are not. The heating power of the former is low to fair while the latter is decidedly high. Most of the coals lean toward gas and coking types, yet the high content of sulphur and moisture are objectionable features, affecting the quality of both the gas and the coke. The Verne seams are coking coals, but the coke is generally so poor that all of the coke made in Michigan is from Ohio or other imported coals. One quality, however, seems to be nearly in common; they all are fair to excellent steam and domestic coals. The coals of Corunna and Jackson were locally favorite steaming coals, that of the former being for years almost wholly consumed by the Pere Marquette railroad. The later mined coals of Saginaw valley, especially of the Saginaw seam, running well above fifty per cent in fixed carbon with little or no sulphur, are much higher in grade. Their steaming qualities are so superior that several mines successfully compete in markets beyond the limits of the state, in spite of the deeply rooted prejudice against Michigan coals. The Saginaw coal in comparative tests with Hocking Valley, a most famous steam coal, proved the superior in several of the tests. (See test by E. C. Fisher.)

Heating Power-Boiler Tests. Under a boiler, the full amount of heat, obtainable in calorimeter or other such apparatus, cannot be practically obtained. The combustion is not perfect. Much of the gas as steam, carbon monoxide, and carbon dioxide escapes carrying away much heat, and other heat is lost in the ash and clinker, boiler material, etc. The kind of boiler, draft, and coal are factors making the amount of heat realized greater or less, as they are good or poor. The amount is highest (55-65% of the theoretical) when unburned air equals one-third of the chimney gas. Coal, showing an average of 7,500 calories, when subjected to a practical test, theoretically should have evaporated 13.37 pounds of water but actually evaporated only 8.17 pounds. Michigan coal of somewhat higher calorage showed the same result, evaporating but 9 to 12 pounds. By convention, commercial evaporation is fixed as the evaporation from a feed water temperature of 100° F. to steam of 70 lbs. gauge pressure. The commonest methods of expressing heating power are in units of evaporation (U. E.), i. e. pounds of water changed to steam at a temperature of 212° F. or British Thermal Units (B. T. U.), i. e. pounds of water raised one degree.

To estimate fully the heating power of coal, a great many factors such as, temperature of feed water, steam pressure, type of boiler, kinds of grates and draughts, size and kind of coal, the amount of ash and clinker, manner of firing, etc., must be taken into account. Comparative tests show mainly what coal is best suited to a given boiler outfit. A coal, ranking first with one boiler might not with another. Michigan coals, to get the best results, usually require a special grate and experience in handling. Thus the absolute efficiency of the same coal in different boiler tests varies much, though, often, the same relative efficiency is seen in all the various series of tests.

The following is a test, showing the comparative value of Hocking Valley and Saginaw coal for a certain boiler outfit, in which, pound for pound, the latter coal is slightly less efficient in actual heating power, but considerably more efficient when the price quoted is considered.

TEST BY E. C. FISHER ON ONE WICKES' PATENT WATER TUBE SAFETY STEAM BOILER.

	Saginaw.	Hocking Valley.
Fuel—Kind of Coal:		
Amount used, lbs	6,092.0	5,808.5
Moisture in coal	5.5	5
Dry coal — lbs	5,757	5,518.08
Dry coal — Per cent	4.2	6.1
Total refuse, lbs	245.5	338.5
Total combustible	5,511.5	5,179.5
Dry coal consumed per hour	575.7	551.808
Combustible consumed per hour	551.15	517.95
Results of Calorimetric Tests:		
Quality of steam	0.9925	0.9927
Percentage of moisture	0.75	0.73
Economic Evaporation:		
Water actually evaporated per lb., dry coal (U. E.)	6.93	6.99
Water evaporated per lb., dry coal from and at 212° F	8.26	8.32
Water evaporated per lb., combustible from and at 212° F lbs.	8.63	8.87
Rate of Combustion:		
Dry coal burned per sq. ft. grate per hour, lbs	25.6	24.5
Dry coal burned per sq. ft. water heating surface per hour, lbs.	0.363	0.34
Rate of Evaporation:		
Water evaporated from and at 212° F. per sq. ft. grate surface per hour, lbs	211.04	204.1
Water evaporated from and at 212° F. per sq. ft. heating surface	3.00	2.90
Commercial Horse Power:		
On basis of 34.5 lbs. water evaporated per hour from and at 212°, H. P	137.9	133.2
Builder's rating, H. P	144.0	144.0
Cost in coal to evaporate 100 lbs. of water from and at 212° F.	cts. 14.4	cts. 15.8
Cost of coal per ton (2,000 lbs)	$2.25	$2.50
Water evaporated from and at 212° F., per lb. wet coal, lbs.	7.8	7.91
Efficiency of boiler, lbs	71.10	....

For more complete details concerning the items taken into account in accurate testing see Vol. VIII, Pt. II, pp. 68-69.

For ordinary purposes, the "Alternate method though much less elaborate, gives results very instructive in a comparative way. These tests consist of twelve hour runs with each coal, keeping the conditions throughout as nearly uniform as possible. Obviously, this is impossible from a standpoint of exactness, but the general average of conditions can be maintained quite satisfactorily. Mr. Edgerton, at the Municipal Water Works Plant of Lansing, obtained the following results from the several coals used:

	U. E.* 1st Series.	U. E. 2nd Series.	U. E. 3rd Series.
Average of Hocking Valley coals	7.38	8.32	....
Saginaw	7.23	....	7.32
St. Charles	....	8.16	7.41
Corunna	6.49	....	....
Williamston	6.51 6.94	....	....
Bay City (Upper Verne)	....	....	7.56
Bay City (Lower Verne)	....	....	6.75

*U. E.—Units of evaporation, i. e. pounds of water evaporated per pound of coal burned.

These figures are much lower than those obtained by Mr. Fisher but the relative values agree very closely indeed. It must be kept in mind that different boiler outfits vary in efficiency in developing heating power. Also one kind of coal may work fine with one type of boiler and not with another. Michigan coals have a tendency to run together on the grate, so that a special kind of grate had to be devised for their use on locomotives. Thus it is not the absolute but the relative values which are the more instructive. The first measures the efficiency of the boiler for the given coal, the latter measures, in a general way, the quality of the coal as compared with other coals.

Boilers are expected to develop about 60 per cent of the theoretical heat values. Those, which do not, are of inferior type or are poorly handled. The three sets of tests given below are very complete and instructive. The sets were made by Mr. Edgerton, preliminary to the awarding of contracts for coal. The first was made in 1898, the second in 1899, and the third ran from June, 1900, to February, 1901.

LANSING WATER WORKS TEST—FIRST SERIES.

Name of coal.	Grade of coal.	Pounds of coal burned during the test.	Pounds of ash.	Pounds of water evaporated during the test; feed water temperature 110° F.=61.89 lbs. per cubic foot.	Pounds of water evaporated per pound of coal.	Price of coal delivered in bins.	Pounds of water evaporated for $1.00.
Cedar Grove	Steam lump	8,471	804	62,581	7.387	$2 45	6,030
Goshen Hill	Run of mine	10,162	995	71,433	7.030	2 25	6,248
Black Diamond	Run of mine	11,106	1,293	70,875	6.381	2 26	5,647
Massilon	Run of mine	10,407	808	72,547	6.971	2 33	5,932
Hocking Lump	Run of mine	11,163	949	74,400	6.634	2 35	5,646
New River	Run of mine	18,765	524	68,471	7.852	3 20	4,907
Hocking Valley	Run of mine	10,706	808	71,618	6.689	2 31	5,791
Cedar Grove	Run of mine	10,000	1,048	65,614	6.561	2 35	5,583
Hocking Valley	Pea	12,845	1,558	75,332	5.864	1 94	6,046
Mingo	Run of mine	9,669	682	71,486	7.393	2 80	5,281
Jackson Hill	Run of mine	10,397	513	71,185	6.846	2 50	5,477
Riverside	Run of mine	9,062	491	74,280	8.196	2 60	6,304
Hocking Valley	Run of mine	11,645	1,021	74,899	6.432	2 34	5,497
Saginaw	Run of mine	10,754	895	67,471	6.274	2 20	5,703
Corunna	Run of mine	15,551	1,440	59,520	5.633	2 25	5,006
South Side	Run of mine	7,896	565	63,076	7.988	2 50	6,390
Wellston Shaft	Run of mine	8,405	120	64,066	7.622	2 25	6,775
Pocahontas	Run of mine	7,089	285	65,428	9.229	3 00	6,153
Not known	Run of mine	10,073	1,097	65,862	6.538	2 09	6,317
Williamston	Run of mine	11,178	....	62,335	5.659	2 40	....
		10,391	440	62,015	6.021	....	....

Michigan coal italicized.

The tests in general show that, while St. Charles coal did not rank in efficiency with Pocahontas, it is better than several other coals and nearly equal to the best Hocking Valley. The practical side of such tests is of great economic importance to consumers by showing in dollars and cents the relative efficiency of different coals with a given plant. The greater cost of some of the coals per ton more than offsets their greater efficiency.

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LANSING WATER WORKS TEST—SECOND SERIES

	Grades of coal.	Pounds of coal burned during the test.	Pounds of ash.	Per cent of ashes.	Pounds of water evaporated during the test. Temp. of feed water 110° F. 62 lbs.=1 cu. ft.	Pounds of water evaporated per lb. of coal.
Montana Coal & Coke Co., clinkers, not satisfactory to burn	Run of mine	11,789	1,142	11.2	74,648	6.332
Castner, Curran & Bullett, Pocahontas, no smoke or clinkers	Run of mine	8,929	892	10.0	83,142	9.312
Michigan Coal Co., St. Charles, Black Pearl; very light clinkers, heavy smoke	Steam lump	11,558	868	7.8	78,616	6.802
J. H. Somers Coal Co., St. Charles, light clinkers, heavy smoke	Steam lump	13,150	1,118	11.8	96,552	7.311
W. H. Vance & Co., Kelley's Creek, no clinkers, heavy smoke	Run of mine	11,500	1,545	13.4	81,034	7.046
M. A. Hanna & Co., Youghiogheny, no clinkers, smoke medium	Run of mine	10,335	1,092	10.6	79,298	7.672
Pittsburg Coal Co., Hocking, no clinkers; good burning coal	Three-quarter lump	10,532	945	9.0	78,132	7.432
Milton Coal Co., Wellston Shaft; light clinkers, smoke medium	Run of mine	10,305	500	4.85	78,306	7.596
Lowery Coal Co., Hocking Congo; clinkers and bad smoke	Steam lump	10,110	905	9.0	70,494	6.972
Lowery Coal Co., Boomer, W. Va.; no clinkers, light smoke	Run of mine	9,825	885	9.0	75,392	7.673
O. W. Shipman Co., Peerless, Cedar Grove; very light clinkers, smoke medium	Run of mine	9,340	740	7.9	69,750	7.470
W. H. Vance & Co., Massilon, no clinkers, light smoke	Run of mine	8,608	670	78	69,006	8.019

LANSING WATER WORKS TEST—THIRD SERIES.

	Date of test.	Coal burned during test.	Ash.	Per cent of ash.	Pounds of water.	Water evaporated with 1 lb. of coal.	Water evaporated for $1.00.
	1900.						
Sandy Creek	June 8	10,124	1,041	10	58,280	5.756	4,343
Boomer R. M.	June 9	8,895	730	8.2	65,410	7.353	5,656
New Pittsburgh R. M.	June 12	9,640	1,105	11	58,590	6.077	4,901
Milton Coal, R. M.	June 13	9,512	594	6.2	63,116	6.635	4,825
Pittsburgh & Wheeling	June 14	8,520	593	6.9	57,350	6.731	5,280
Somers Coal Co., St. Charles	June 16	10,110	895	8.8	64,480	6.377	5,091
Somers Coal Co., St. Charles, different shaft	June 21	9,770	785	8	62,992	6.447	5,137
Pere Marquette Steam Lump (No. 2 Shaft)	June 22	9,350	595	6.4	59,210	6.332	5,389
Michigan Coal & Mining Co., Steam Lump	Nov. 11	14,626	1,255	8.6	95,604	6.536	5,335
	1901.						
Pittsburgh Coal Co.	Jan. 4	13,033	1,510	8.6	101,982	7.820	6,133
Silver Mather Co., Bay City	Feb. 8	15,916	3,180	19.9	93,310	5.846	5,314
Pittsburgh Coal Co., No. 8	Jan. 20	14,890	1,835	8.1	103,168	6.928	5,542
Pittsburgh Coal Co., three-fourths coal	Jan. 10	12,970	1,490	11.5	101,122	7.796	5,846

Analyses of Coal. The analysis of a coal shows the amount of possible available combustible, but this does not mean that it is all used in combustion. The physical and chemical qualities of a coal affect its burning qualities very much. For instance the tendency of some Michigan coals to run together often causes very unsatisfactory results, for special grates and experience in handling such coals are required to insure the highest efficiency. The high content of water, vaporized into steam, carries away no negligible quantity of the heat generated. So many other kindred factors have to be taken into account, that analyses must be taken to represent more the probable value of a coal than its absolute.

TABLE OF ANALYSES.

	Moisture.	Vol. Mat.	Fixed C.	Ash.	Total sulphur.	B. T. U.	Coke Bu.
*Pocahontas	0.50	20.43	74.07	4.98	0.605	14,579	....
§Hocking Valley	5.42	35.27	52.79	6.52	2.09	13,151	....
Pittsburg	1.49	32.57	57.87	8.07	1.13	13,867	....
Massilon	1.7	40.48	51.2	6.55	2.99	12,105	....
Robert Gage (Saginaw Seam)	2.37	35.67	58.47	2.46	1.03	13,438	....
Barnard (Saginaw Seam)	9.28	31.67	53.70	5.35	.98	12,456	59.5
Somers No. 1 (Saginaw Seam)	7.79	34.74	52.58	4.89	1.01	12,836	....
What Cheer (Saginaw Seam)	2.864	‡91.283	....	5.853	0.128	13,383	....
Wenona Coke	1.68	3.12	79.46	15.74	7.41	....	....
Wolverine No. 2	8.92	36.49	51.92	2.67	1.49	12,987	....
Wolverine No. 3 (Upper Verne)	4.14	45.70	42.14	8.02	3.53	12,520	....
Wenona (Upper Verne)	3.78	41.18	49.34	5.70	2.50	....	55.04
Wenona (Washed)	3.78	41.40	50.48	4.34	1.82	....	....
Central (Lower Verne)	4.52	40.57	42.16	12.75	6.92	12,128	....
Michigan (Lower Verne)	5.01	39.62	41.67	13.70	6.66	12,183	....
Sebewaing	6.09	39.54	46.06	8.26	5.72	12,714	....
Jackson	5.93	46.59	44.64	2.84	3.07	13,502	....
Owosso (Verne)	7.59	35.70	52.58	3.76	1.50	13,016	....
Grand Ledge (Verne)	7.00	39.10	46.40	7.50	3.42	....	....
Upper Rider	....	45.02	45.50	9.48	4.19	13,838	....

*Calorimeter tests upon dry coal.
§Analyses upon thoroughly dried coal.
‡And fixed carbon.

The analyses of Michigan coals by different chemists vary considerably in the item of moisture and somewhat in volatile combustible for the same grade or vein of coal. This arises from the fact that analysts have not agreed at all in drawing the line between moisture and volatile combustible. Since the usual high hygroscopic content of water is one of the factors affecting quite markedly the heating and gas making qualities of our coals, it is important to have rather accurate information. In some of the analyses of the Saginaw coals given in the table of analyses (Chap. III), the water content is much below the average (usually above 7%) for this coal and, very possibly, part of the moisture was included in the volatile combustible.

From the several analyses, it can be seen that some of the coals are remarkably low in ash. Many analyses, made by different investigators, seem to show that the sulphur, is always in almost exact proportion for combining with the iron. This means no excess sulphur in the form of sulphates. A general principle can also be deduced for the relations between the ash, fixed carbon, and volatile combustible. The fixed carbon drops faster than the volatile combustible, when slate, bone, or cannel coal is introduced. The amount of ash is thus very indicative of the heating power of a coal.

Summary. Only three seams of the 10 to 12 or more seams have been well developed possibly excepting the Middle Rider. All are bituminous, rather high in moisture, inclining toward gas coals and passing into low grade cannel or bone coal. The Upper Verne or Monitor seam apparently is the only gassy one and is a coking coal though a poor one with a medium amount of sulphur. The Upper Rider and the Verne coals are near the lignite end of the bituminous group. Probably burial has been so shallow, that the original woody material has been little changed.

The Lower Verne, the next seam, often close enough to be mined with the Upper Verne is decidedly poorer in grade. It is a coking coal high in sulphur and ash and often below .50 in fixed carbon.

The Saginaw seam is of much higher grade, usually having well above 50% of fixed carbon, with little ash and sulphur. Its higher moisture content than the Verne coals is a bad quality, especially for gas making with ordinary producers. It is also unlike the Verne seams in not being a coking coal. Its other good qualities make it a fine domestic coal and a steaming coal much in favor with railroads, it is said.

Some of the East Saginaw mines possibly have their shafts in the middle Rider just above the Saginaw seam. The decidedly lower grade of the coal in some of these mines, certainly is indicative that the Saginaw seam either varies a great deal in quality in a short distance, or that the mines in East and West Saginaw are in wholly different veins.

CHAPTER IV.

EROSION AND DISTURBANCE OF COAL.

After the formation of the beds of coal, present and past rivers have cut into them and carried them partly away. Some of the channels are occupied by our present rivers, others are filled with unconsolidated gravel, sand, till, etc., and still older channels are filled with rock, usually sandstone. This gives rise to three kinds of channels,—open channels, gravel channels or "washouts," and sandstone channels.

Unfortunately, for the early development of coal mining in Michigan the open channels with exposures of coal along their sides are not at all numerous or deep. The development of the Saginaw and Bay county veins would have been tardier still had it not been for the numerous drillings for salt and water. As mentioned previously, the coal basin is covered with a thick mantle of drift varying from a few feet to six hundred or more, through which the bed rock exposes itself at few and scattered places, chiefly of course along stream courses. As the drift is thinner on the eastern, southern and southwestern parts of the basin, it is in these that most of the outcrops occur. Beginning on the east of Saginaw Bay, the first outcrop occurs along Coats Creek, near Tuscola where coal was dug for many years from the bank. Coal measure sandstones also occur in the bed of Cass River, a little way above the town. Going south the next exposures are on Flint River near Flushing and along the Shiawassee from just above Corunna down to Saginaw county. At intervals, other outcrops occur all along the southern border of the basin in the stream beds about Jackson, Chelsea, Eaton Rapids, and Dimondale. Exposures also occur on the Cedar and the Grand from Williamston to nearly six miles below Grand Ledge. The thickening of the drift on the southwest allows only a few glimpses of coal measure sandstone as at Ionia and in Kent county. But, over the whole northwestern and northern parts of the coal basin, the 300-600 feet or more of drift completely conceals the bed rock from Kent county north around to Rifle river in Arenac county. The center of the coal basin is also covered heavily with drift.

None of the rivers, except the Grand at Grand Ledge, has cut valleys deep enough to expose coal on the banks, which can be effectively worked. The small mines near Grand Ledge are the only self draining mines in the state. All the important ones are under a greater or less hydrostatic pressure and require costly pumping machinery to keep them from flooding. The abundance of water, one of Michigan's greatest blessings, is not such to the coal operator. The rivers in the states to the south, as in Ohio have cut much deeper valleys, extensively exposing the coal along the hillsides, so that mining is easy and inexpensive. It is this factor together with that of the much thicker veins that allows the Ohio operator in seasons of dull iron trade, to lay down, at a small profit, his excess coal at the tipples of Michigan mines, at prices ruinous to Michigan operators.

Drift Filled Channels. The states to the south were somewhat plastered over with drift, but Michigan received two full coats; first a rough one of gravel and till from the Ice Sheet itself and then a finishing coat from the deposits of the Great Lakes system, whose waters were 200 or more feet higher than now and flowed southwest from a lake in Saginaw Bay.

Previous to the invasion of the ice-sheet, pre-glacial streams had carved steep channels 100 to 150 ft. deep or more in the coal measures. Remove the drift and the coal would be well exposed along the channels. Many of these channels have been found by boring and the courses of some, have been fairly well determined wherever the borings have been numerous enough. In a general way, many of them unite with a trunk channel which probably passes from near the head of the region of Saginaw Bay to the southwest toward Alma and then veers to the northwest, entering Lake Michigan below sea level somewhere between Manistee and Ludington.

These channels locally cut out a great deal of the coal, especially the upper veins, and, since bed rock is effectually concealed by the thick screen of drift, the amount and distribution of coal in a given tract is very uncertain. It may be nearly all cut out or but little. Drillers often find bed rock and coal at comparatively shallow depths, yet, a few hundred feet away, bed rock is far beneath the surface, with no trace of coal. It is this uncertainty in finding the coal that makes it hazardous for explorers with limited means, to attempt proper development work.

In Ohio and Kentucky, the soil mantle is so thin that the coal is easily discovered and the areas are readily determined. The beds are thicker, more persistent, and have fewer washouts, thus require very little drilling for proving. Michigan areas require thorough proving by the drill before any approximation can be made of the amount and extent of workable coal.

"Toward an outcrop or washout, the coal is likely to rise" is a rule of possible practical value. This phenomenon, observed at Grand Ledge and at other places, may be due possibly to the fact that outcrops are more liable to appear in erosion channels along faults or anticlines.

Sandstone Channels. Sandstone Channels, like the "washouts," cut out the coal, but unlike them, are filled with rock,—sandstone nearly always. These represent the channels of streams existent at the time the coal was formed or, at least, shortly after. These streams cut out the coal measures depositing sand, now sandstone, in the channels. But, in some cases, where we have a heavy sandstone cutting out the coal for a considerable distance, it is more probable that the coal was never laid down, the sandstone representing the ridge of land cutting off the lagoon or basin in which the coal was formed. Real sandstone channels, however, are positively known elsewhere, so doubtless they exist in the Michigan formations. For instance, Mr. Liken near Sebewaing found three feet of coal 36 feet from a previous boring, which, at the same level, was in the midst of over 20 feet of sandstone.

These sandstone beds give trouble as they let in much water and cut out the coal as well. If the absence of coal is due to a cutting down from above it is less liable to be cut out as extensively as it would in the case of a cutting out from below.

Faults or Displacements. Coal beds commonly show disturbance, interruption, or deterioration. Faults are displacements, which in coal beds are almost always normal, that is, the fault plane slopes toward the side which dropped, just as though the coal had slid down. The fault planes are usually occupied by clay seams or veins traversing the coal "sulphur partings," that is veins or seams of iron sulphide or "Spar seams" or veins of calcite, gypsum or other white mineral.

Miners use the term fault very loosely and apply it to anything that cuts out the coal, be it rolls, horsebacks, bars, channels, or sandstone. Faults are common, though usually of small throw or displacement in coal, as would be expected from the slumping due to the settling and compacting of the vegetable material in the process of coal formation. The faults at Sebewaing and Jackson are the two best known instances of faulting in Michigan. The throw is hardly more than two feet. The coal rises toward the faults as though there had been "drag," commonly observed in larger faults. The slipping along the fault plane has polished the surfaces of the coal and slate into bright shining faces called slickensides.

Sulphur partings are streaks of pyrite or marcasite more or less mixed with other impurities. They are found not only along fault planes but often they follow the partings of the coal or the bedding planes. These thin streaks affect the value of the coal as they are often the source of the high sulphur content of some coals like the Lower Verne. It is impossible to get the pyritous material all out, or to prevent the thin streak near the roof of the Lower Verne from being included. The waste pyrite of the Lower Verne seam is large enough to be of economic importance, if a practical way is devised for using it in fertilizers or for cheap large scale disinfection.

Before the Sebewaing mine was abandoned, an attempt was made to mine the pyrites for commercial purposes using the coal as a by-product. This, however, was unsuccessful at the time, but may have future possibilities.

CHAPTER V.

DEVELOPMENT OF COAL MINES.

As has already been noted here and there on previous pages, there are some peculiarities in the occurrence of coal in Michigan, which have retarded and will continue to more or less retard its further development. All, but the unimportant "drift" coals around Grand Ledge, are below the water table and largely in artesian well country. Some coal areas are much wetter than others, because the overlying beds are porous sandstones and drift. Sometimes the roof is a porous sandstone or is full of fissures, allowing free circulation of water, but usually the water comes from the coal itself or from the foot-walls. The coal basin is full of wet spots such as troughs, "washouts," and depressions, which act as catch basins. Slopes or troughs leading down to the coal have been encountered in sinking shafts at Jackson, Elk, Williamston, and Corunna with disastrous results, as the water could not be kept out. Heavy beds of sand and gravel in the drift carry a great deal of water and prove formidable obstacles to sinking shafts. The Auburn Coal Company lost two shafts in quicksand and nearly lost a third. (See Lane 1905.) At best, the amount of water to be handled will be a very serious problem. In the past, this problem has been a most annoying one and a cause of more than one failure. The heavy cost of adequate machinery and of raising the water to the surface consumes a large part of the operator's margin of profit. For the most economic handling, shafts should be sunk into the lowest part of the coal, so that all of the water will run toward the pumping shafts. To find the most advantageous point for beginning mining operations requires much preliminary drilling.

Deep drift channels should not only be avoided because of their large water content, but, also, on account of the too often weak and treacherous roof over the coal under such channels. Coal without an adequate roof to support the overlying strata is worthless as a mining proposition. This condition often obtains in drift filled channels, and near the margin of the coal basin. The early discoveries of coal along Rifle River come to naught on this account and several mines have had to be abandoned. Some of the larger mines have poor roofs of rotten shale or "slate" and require much timbering. Frequently a shale roof much desired from its impervious qualities, slakes with exposure to air and scales off, making work extremely hazardous. The Gage Mine No. 2 at St. Charles has such an unstable roof, that it has been a constant source of trouble and expense. A new shaft at Owosso, sunk by the Robert Gage Company, was abandoned on account of the poor "slate" roof.

The coal seams are some 10 or 12 in number with only three developed to any great extent. They are somewhat disturbed, quite variable in thickness, extent, quality and character. The thickest veins rarely run more than three to four feet and, while some of the others are locally of workable thickness, most of them are too prevailingly thin for possible exploitation under present economic conditions.

Dr. H. M. Chance reported to the State Tax Commission that veins in Michigan much below three feet in thickness could not be worked at a profit, at present prices, and under the average conditions. The thin veins at Grand Ledge owe their exploitation to their natural system of drainage and ventilation, or to their association with so-called fire clay, which is of far more value than the coal. Reported thicknesses of five to six feet of coal are almost always exaggerations. The four and five foot veins are few and far between. The old Wenona mine had one of the thickest veins in the state, being above 4 ft. 6 in. in thickness.

With all these discouraging conditions, Michigan operators, on the other hand, may be thankful, that fire damp and coal dust explosions are hardly known, while noxious gases such as choke damp are little troublesome, the mines are too wet for dust explosions. The United Coal Co. and the Pittsburg Coal Co. mines are the only ones which have had any gas. Good precautions as to thorough ventilation and examination of the working places have prevented any serious trouble. Only a few miners have ever been injured by such explosions in Michigan mines.

Principles to guide Exploration. 1. Favorable places for preliminary exploration lie in a belt a few miles within the coal margin. Nearer the center of the basin coal beds are liable to give way to shales, unless other beds of later and higher horizon come in. From records in Bay county there seem to be coals of higher horizons than the Salzburg, though their existence is inferred from rather meagre records. Coal nearer the margin is apt to be cut out by some channel or may lack sufficient roof.

2. Coal once located, though thin, may thicken especially in

a direction parallel to the margin. Further borings may locate a workable area. If the money spent in haphazard drilling about the state, could have been used in proving known favorable areas, the results undoubtedly would have been far more satisfactory.

3. Coal generally rises toward the margin, except for minor undulations, thus shafts should not be located until the lowest part of the coal vein has been determined by drilling. This is essential for the most economic handling of the coal and water.

4. Up to the present, most of the exploration and development has been along the eastern and southeastern side of the basin. A line from Sebewaing to Jackson and a parallel one from just west of Bay City toward Grand Ledge would mark tow belts containing practically all the mines, which have mined coal in any quantity. The more recent prospecting and exploration has been to the west and northwest of Bay City toward and into Midland and Arenac counties. Explorations near Flint promise much and recent developments indicate a large body of workable coal. Along the southwestern margin the drift is comparatively thin and as coal has been found in several places northeast of Bellevue, Eaton county, in veins reported to be four to six (doubtless the higher figure is an exaggeration) feet thick. This part of the field looks promising and deserves further exploration. (See Fig. No. 12.) Much coal has been found in the drift of Montcalm county and the valley of the Upper Muskegon river. The coal must have come from underlying coal beds. The drift is so deep (300-600+), however, that little exploration has been attempted.

5. Most of the coal basin from the center westward and northward to the margin and beyond has been deeply covered with drift, so that exploration for coal alone would probably be too expensive to pay. Even if coal was found in good thickness and extent, the wealth of water in the drift to say nothing of the probably quicksand beds, would make the sinking of shafts very difficult indeed and the mining of the coal very expensive.

6. The finding of a good bed of coal near the surface is not an unfavorable sign of more coal below. Many prospectors stop at the first good seam, when the probabilities are that more coal could be found by going deeper. The suggestion also has been made that much of the drilling in the past has been altogether too shallow.

The map in Figure No. 12 gives a general idea of the proven areas of coal, and the possible ones, and shows how relatively small is the percentage of workable coal to the area of the whole basin. Either the workable beds are woefully insignificant in extent or there are many yet to be found. Probably there is a good deal of truth in both.

Methods of Exploration and Developing. In general, since the drift is so thick, test pitting or digging wells down to the coal is wholly impracticable. The abundance of water, treacherous veins of gravel and quicksand, and large boulders would form almost unsurmountable obstacles, except where the drift is very thin. Then the coal beds being on the whole near the horizontal would probably be concealed under heavy masses of sandstone. If exposed, they would be useless as a mining proposition from lack of good roof.

The early prospecting for coal in Michigan was mainly done by churn drills. These are very satisfactory for finding the coal and running it into a "valley" or "swamp," but do not give sufficiently accurate data concerning the thickness of the beds. Black shale usually occurs above and below the coal, and it is hard to tell by a churn drill just where the shale ends and the coal begins or vice versa. The records from churn drills always tend to exaggerate the thickness of a coal bed, so that many areas have never yielded nearly as much coal as had been previously estimated from the drill records.

In the last few years, core drills have been used very largely, especially in proving coal territory. They give much more reliable data concerning the thickness of beds and the estimates, based upon their records, more nearly approach the product actually realized afterwards in mining.

CHAPTER VI.

VALUE OF COAL LANDS AND COAL RIGHTS.[1]

The value of coal lands in Michigan depends primarily upon the geographical position of the Coal Basin. It is the only one lying in the Great Lakes system, and is in the midst of a rich and populous manufacturing region. Further, the means for the distribution of the coal product is almost unparalleled through the network of railroads traversing the region, and the system of water routes with Saginaw River and Bay penetrating to the very heart of the most productive part of the Basin. It is this central position with markets almost at the shafts of the mines, that made possible, during the years 1896 to 1907, the unparalleled growth of Michigan's coal industry, in spite of other most discouraging conditions.

It must be borne in mind, that Michigan Coal Measures are buried under a deep deposit of glacial materials, carrying heavy water bearing strata, and dangerous quicksands, that the workable areas are smaller, more irregular, scattered, more variable, thinner veined, and of lower grade then in other fields, and that the expense of prospecting and proving up the areas, of sinking shafts, of mining thin veins, of timbering the bad roof, and of handling the abundance of water is far greater than in the states to the south. Higher mining and wage scales, besides a more generous computation of the extra allowances for narrow work, etc., tends to swell the expense roll in Michigan mines.

As can be seen from the table of production the average cost of placing a ton of coal on the car in 1910 was $1.79 or about 60 to 80 cents more than that in West Virginia. Of course, a large part of this increased cost is due to keeping up the mines during the summer. The water makes it imperative that the pumps be kept working, so that many operators mine throughout the summer, marketing the coal at a loss.

As an offset, the Michigan operator has markets almost at his shaft, especially is this true in the region of Saginaw and Bay City, and the territory to the north and west. Thus the freight rates run from 25 cents up, and rarely exceed 70 cents, and the

[1] H. M. Chance, Appraisal of Mining Properties, Report of State Board of Tax Commissioners, 1911, p. 66.

difference between these and the ones from Ohio and West Virginia forms a protective tariff. The rates from Ohio range from $1.40 to $1.50 and more per ton and $1.65 to $1.85 per ton from West Virginia. Subtracting from these the amount (70-80 cts.) of the increased cost of mining in Michigan, there is a net margin of protection for the Michigan operator, ranging from nothing for the more remote deliveries to 45 cents or more for purely local ones.

But, another factor has to be considered and this is the quality and the use of the coal. A ton of average Ohio and West Virginia coal is worth in actual heating power more than a ton of average Michigan coal. This difference in quality, measured in British Thermal Units (B. T. U.) has a money value ranging from 20 to 30 cents. Then obviously Michigan coals cannot compete with the former at the same prices. The high content of water and usually of sulphur and the generally lower average of fixed carbon do not make them as efficient for all around heating purposes as the dryer coals low in sulphur. For steaming purposes and domestic uses the Saginaw Coal is a very superior coal, but unfortunately a large part of our coal product comes from the Verne and other veins which are decidedly inferior to the first, yet the latter are what are called good steam and domestic coals.

For coking and gas making, Michigan coals are no competitors of those coming from Ohio or West Virginia. Not that coke or gas cannot be made from them for the Verne Coals are both coking and rich in gas, but that the water or sulphur content or both makes them less fitted for making coke and gas satisfactory for commercial purposes.

It is the lower quality that tends to wipe out the margin of protection so that in periods of depression in the iron trade as in 1908, the Ohio operator can place his excess coal at a small profit on the market at prices ruinous to the Michigan operators.

From the preceding facts it is seen that the Michigan coal lands have a value over and above their value as agricultural lands.* This may be reckoned at 10 cents per ton for coal to be immediately mined. This small value represents the difference between the average cost of putting the coal on the cars and the average price received. To find the total amount of coal per acre of an area, the average thickness must be known. The amount of available coal, that which can be mined at a possible profit, is hard to determine. Experience has shown that, in Michigan, hardly half of the computed tonnage is ever realized in actual mining. This

* See H. M. Chance, Appraisal of Mining Properties, 1911, pp. 66-75.

is due partly to incomplete or unreliable drilling, which has not shown channels or sudden and unexpected variations in thickness, or revealed the presence of a weak or treacherous roof. The first reduces the total amount of coal present, the second, the amount of workable coal, and the third, the available coal. In the last case a large amount of coal must be left in pillars for the support of the roof. Indiana, Ohio, and West Virginia give yields per acre foot (an acre of coal 1 ft. thick) of 1,200 to 1,350 tons, but in Michigan the yield rarely runs much above 1,000 tons per acre foot. Thus a three foot vein of coal in Michigan would yield about 3,000 tons. With such a yield, at the base price of 10 cents per ton the coal land would be worth $300 per acre. But this is too high, for coal remote from the shaft may not be mined for a term of years and thus should be discounted for such estimated period. As undeveloped but proven mining properties sell at about half the price of developed ones, 5 cents a ton would represent the base price. But this must be discounted according to the length of time elapsing before mining begins and the number of years in the average life of a colliery, so that the present value of a ton of coal in undeveloped but proven property has been estimated at 1¼ cents a ton, giving a value of $37.50 per acre for coal land like that noted above. The average cost (See Ann. Rept. Michigan Bureau of Labor, 1911), of mining a ton of coal in 1910 was $1.79 and the average selling price (See U. S. Min. Resources, 1910), was $1.91, making an average net profit of 12 cents per ton. Some mines averaged better, some much less, and some sold at a loss. (See Production and Distribution.) The value given above for the cost is somewhat higher than that given by Chance, who quotes the cost at $1.60 per ton. If this is correct and the selling price, $1.91, is not correspondingly higher, the margin of profit would be considerably larger. This is hardly possible as such a margin would be large enough to successfully compete with outside coals under almost any conditions of trade. Unproven coal land can hardly have a value above that for agricultural, or purposes other than mining, when investors have not and do not now purchase mineral rights to such lands.

The map in Fig. No. 12 gives a general idea of the proven areas of coal. A glance is sufficient to observe the relatively small proportion of proven coal land as compared with the area of the whole basin. The areas plotted do not refer to the areas where coal is known to occur, but where it is known to occur in thicknesses great enough for profitable mining. The following table

PROVEN COAL IN MICHIGAN.

County.	Acres.	Tons.	Appraised value.
Bay	4,607	14,945,746	$484,709
Saginaw	3,297	9,556,583	350,924
Midland	343	1,029,000	12,862
Tuscola	10	35,000	3,500
Shiawassee	260	780,000	9,750
Genesee	936	2,836,333	
Ingham	0		
Eaton	0		
Clinton	0		
Jackson	0		
Total	9,453	29,182,662	$861,745

Average value per acre of appraised land $101.18.

gives the area of proven coal lands by counties: This table and the map were prepared in 1911 by Mr. H. F. Lunt as a part of Dr. H. M. Chance's report to the State Board of Tax Commissioners, on The Value of Coal Property and Coal Rights in Michigan. The data necessary for such map and table was compiled from the mine and property maps of the operators or owners. Either the thicker areas are extremely limited in extent, or they remain as a hidden reward of discovery for future prospectors.

CHAPTER VII.

PRODUCTION

Although coal mining began in Michigan more than seventy-five years ago, it was not till 1896 that Michigan began to be reckoned among the coal producing states. As can be seen from table of production, there was a steady but extremely slow increase from 2,320 tons in 1860, the first recorded production, to above 135,000 tons in 1882, the 100,000 ton mark being realized only in the years from 1880 to 1882 inclusive. The panic in the early eighties wholly demoralized the struggling industry, so that the production fell to about 35,000 tons. The recovery was very slow indeed. In fact, the years following, up to 1895 were ones of alternate indifferent success and failure. The severe financial depression of 1894 again reduced the production to little more than 45,000 tons or 10,000 tons less than it was twenty years before.

As has been noted on other pages, 1896 signalized the rapid sinking of shafts in Bay and Saginaw counties. The production of the year following is most suggestive of this activity in coal mining, as the production had increased from about 93,000 tons in 1896 to more than 223,000 tons. The production in 1901 was 13 times that of 1896, or over 1,240,000 tons. Each successive year saw the production grow by leaps and bounds until it reached the high water mark of over 2,000,000 tons in 1907.

It will be recalled that the sale of Michigan coal is limited mainly to its home markets. It is true that the cities along the Lower Lakes had been growing rapidly and consuming the coal product, but coal mining wholly outstripped them in the rapidity of its growth, so that, in 1907, production was much greater than their capacity to consume. The year following thus shows a decided falling off in production, which has continued to the present.

Of course, other factors were influential in bringing about this condition of affairs. The capacity for consumption doubtless had been exceeded before this, but local strikes and those in other fields at different times, as in 1902 and 1906, tended to reduce any surplus and even cause deficits in the coal supplies, which allowed great increases in production without serious consequences. The banner production of 1907 glutted the coal markets so that coal prices fell to points ruinous to operators. To make matters worse, the dull iron season in 1908 following the financial depression of 1907, caused the Ohio operators to seek new markets for their surplus coal. With cheap mining facilities, they were able to put their product at a small profit upon Michigan markets at prices, that meant bankruptcy to Michigan operators.

With the increase in production, there grew up also the keenest competition among the numerous producers. As a result of local competition and that from the Ohio and West Virginia districts, some of the weaker operators were forced out of business in 1909. In order to cut out the ruinous local competition, to reduce mining costs, and to better adapt their output to the demands of trade, many of the operators had consolidated prior to 1906. The consolidation has continued with most evident good results, seen in the better equipped and better managed mines. The output also has been so adjusted to the demands of trade that equilibrium between production and demand seems nearly accomplished and Michigan operators may soon be enabled to earn profits on a par with those earned in other districts. It may not be too optimistic to believe that the coal mining industry is, in a fair way, of attaining a stable and satisfactory industrial basis.

CHAPTER VIII.

MINING METHODS.

The thin and variable seams of coal, the treacherous shale roofs, and the abundance of water are the three factors determining the methods of mining in Michigan.

The first means that, in general, operators must pin their faith to good pumps. The pumping shaft should reach the lowest part of the coal so that all water will run to the pumps, thus keeping the entries dry. In the case of the dry mines of Ohio and West Virginia, the operators, during the summer months, when coal prices are lowest, can close down without facing a heavy pumping expense in the following fall. This also enables them to mine a minimum amount of coal with loss. In Michigan, the wealth of water makes it imperative that the pumps be kept going. In order to keep the pumping charges at the lowest average, many of the mines are kept in operation at a loss during the summer.

The mines at Grand Ledge, due to the deep channel cut by the river, are dry and it is this fact together with a natural ventilation that has made the mining of such thin veins of low grade coal possible. The workings now have been extended so far from the shaft openings that water is beginning to be troublesome.

The roof of most of the seams in Michigan is a black shale. Unfortunately this, though apparently hard and firm when first exposed, often slakes with exposure to air and flakes off. Such roofs require a great deal of support. Usually large pillars of coal are left standing for this purpose, but these cut out a great deal of coal per acre. The low yield of about 1,000 tons per acre foot is largely due to the use of the room and pillar system. Timbering is more or less resorted to, but adequate timber is now not only very expensive but almost unobtainable, due to the exhaustion of the state's timber supplies. Heavy timbering must accompany robbery of the supporting pillars of coal.

From practical experience, a four foot vein can be worked as cheaply as one thicker. The mining of thinner veins is more expensive on account of the narrow working quarters and the greater amount of dead work. Naturally the average cost per ton in mining a 4 foot vein is less than that for a 3 ft. From Dr. H.

M. Chance's investigations, it appears that veins less than 2 ft. 6 in. in thickness cannot possibly be mined at a profit under present mining and economic conditions. Seams less than three feet in thickness are doubtfully workable, unless under favorable conditions. Of course, in mines working beds more than 3 feet thick, it is very possible to extend operations into areas much thinner in thickness providing the coal is of good quality and the roof good.

Often, in the best of coal areas the veins decrease to less than workable thickness. This local thinning together with the general thinness of the seams in Michigan has much hindered the introduction of mining machines. Michigan operators have lagged behind in up-to-date methods of mining. Shooting from the solid in thin veins always results in much slack or waste coal. A small charge of explosive merely loosens up the coal, so that it would have to be tediously picked out. On the other hand, a larger charge shatters the coal, so that it quickly deteriorates upon exposure to the air and sun. Miners generally use the larger charge, resulting in a considerable loss to the operators.

Mining machines were originally designed to meet the conditions, obtaining in fields where the veins are much thicker, so they were not adapted to the narrow workings common in Michigan. Naturally, the first attempts to use these machines were far from satisfactory, and a wrong impression grew up among the operators as to their practical value, but some types were found to be better adapted to the conditions and have given very satisfactory results. Some of the larger mines now use machines almost exclusively except in very narrow workings. Many of the smaller mines, and a few of the larger ones still persist in the old wasteful methods of shooting from the solid, though operators, in general, are now realizing that the best methods and the best equipments are absolutely necessary for successful mining in Michigan.

The first coal cutting machines were introduced in 1898 and materially increased the quality as well as the quantity of coal mined. They were so successful that twenty-five such machines were used the following year. The number gradually increased until 1908, when the maximum number of 120 was reached, but the rate of introduction of the cutting machines did not keep pace with the growth of the industry, so that, after 1905, the percentage (about 30%) of machine mined coal did not increase materially until the present year when the percentage was nearly forty.

The Mines. The mines are mainly in Saginaw and Bay counties, the first having sixteen and the latter twelve in active operation out of the total of thirty-seven for the state. These mines produced upwards of 92 per cent of the total mined in the state. Saginaw county up to the past year, had led by a good margin but the greater development in Bay county in the last year enabled the latter to take the lead as can be seen in Fig. 13. In order to mine coal the most economically and thus be able to compete more successfully with outside coals, a number of mines prior to 1906 had consolidated under the firm name of The Consolidated Coal Company. The mines operated and controlled by this corporation includes the following active mines: Saginaw, Northern ("Jimtown"), Uncle Henry, Riverside, Central, Shiawassee, Barnard, Wolverine No. 2 and No. 3. This organization also has three new mines ready for operation as soon as the present market conditions improve.

The Robert Gage Coal Co., and the Handy Bros. Coal Co., are two other firms having a group of large mines. The three organizations own or control 18 of the 31 active mines. It is largely due to the united efforts of these three organizations that much of the progress in coal mining has been made. The management and the equipment in all three is much above that possible under the old regime of independent operators, each competing against the other, with disastrous consequences to all.

The general expenses are so much less in management, etc., and the ability to produce through up-to-date equipment is so much greater than formerly, that Michigan coal industry bids fair to hold its rightful share of the local trade against outside competitors.

PRODUCTION OF COAL IN MICHIGAN, 1860-1910, IN SHORT TONS.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1860	2,320	1871	32,000	1882	135,339	1893	45,970	1904	1,342,840
1861	3,000	1872	33,600	1883	71,296	1894	70,022	1905	1,473,211
1862	5,000	1873	56,000	1884	36,712	1895	112,322	1906	1,346,338
1863	8,000	1874	58,000	1885	45,178	1896	92,882	1907	2,035,858
1864	12,000	1875	62,500	1886	60,434	1897	223,592	1908	1,835,019
1865	15,000	1876	66,000	1887	71,461	1898	315,722	1909	1,784,692
1866	20,000	1877	69,197	1888	81,407	1899	624,708	1910	1,534,967
1867	25,000	1878	85,322	1889	67,431	1900	849,475		
1868	28,000	1879	82,015	1890	74,977	1901	1,241,241		
1869	29,980	1880	100,800	1891	80,307	1902	964,718		
1870	28,150	1881	112,000	1892	77,990	1903	1,367,619	Total	18,997,621

DISTRIBUTION OF COAL PRODUCTS OF MICHIGAN, 1886-1910, IN SHORT TONS.

Year.	Loaded at mines for shipment.	Sold to local trade and used by employes.	Used at mines for steam and heat.	Total product.	Total value.	Average price per ton.	Average number of days active.	Average number of employes.	Number of machines used.	Total mined by machines.	Per cent mined by machines.
1910	1,355,819	110,473	68,675	1,534,967	2,930,771	$1 91	211	3,575	....	570,489	38
1909	1,619,221	95,195	70,276	1,784,692	3,199,351	1 79	....	3,496	101	511,895	28.70
1908	1,674,425	87,223	73,371	1,835,019	3,322,904	1 81	207	4,247	120	535,543	29.18
1907	1,792,598	129,434	113,826	2,035,858	3,660,833	1 80	234	3,982	103	606,718	29.8
1906	1,189,972	106,538	49,828	1,346,338	2,427,404	1 80	173	3,971	110	417,073	30.98
1905	1,350,584	66,728	55,899	1,473,211	2,512,697	1 71	186	3,696	106	432,266	29.34
1904	1,270,414	58,009	14,417	1,342,840	2,424,935	1 81	183	3,549	85	310,007	23.09
1903	1,203,166	123,677	40,776	1,367,619	2,707,527	1 97	222	2,768	46	180,943	13.23
1902	818,687	117,978	28,053	964,718	1,653,192	1 71	171	2,344	58	196,248	20.34
1901	1,158,096	44,749	38,396	1,241,241	1,753,064	1 41	247	2,276	31	177,669	14.33
1900	792,679	40,258	16,538	849,475	1,259,683	1 48	261	1,704	33	191,577	22.55
1899	574,280	34,191	16,237	624,708	870,152	1 39	232	1,291	25	64,055	10.20
1898	232,155	75,622	7,945	315,722	462,711	1 47	245	715	7	1,456	0.46
1897	188,636	24,686	10,270	223,592	325,416	1 46	230	537	....	....	....
1896	83,150	6,547	3,185	92,882	150,631	1 62	157	320	....	....	....
1895	80,403	27,019	4,900	112,322	180,016	1 60	186	320	....	....	....
1894	60,817	7,055	2,150	70,022	103,049	1 47	224	223	....	....	....
1893	27,787	16,367	1,825	45,979	82,462	1 79	154	162	....	....	....
1892	27,200	45,180	5,610	77,990	121,314	1 56	195	230	....	....	....
1891	53,113	21,515	5,659	80,307	133,387	1 66	205	223	....	....	....
1890	57,100	12,885	4,902	74,977	149,195	1 99	229	180	....	....	....
1889	53,104	9,110	5,217	67,431	115,011	1 71	....	....	....	....	....
1888	....	....	....	81,407	135,221	1 66	....	....	....	....	....
1887	....	....	....	71,461	107,191	1 50	....	....	....	....	....
1886	....	....	....	60,434	90,651	1 50	....	....	....	....	....

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Distribution of total product.				Total value.
			Loaded at mine for shipment.	Sold to local trade and employes.	Used at mine for steam and heat.	Total quantity.	
BAY COUNTY:							
Black Diamond	Black Diamond Coal Mining Co	Bay City	No. 7 min	e of Robt.	Gage Coal	Co.	....
Monitor	Handy Bros. Mining Co	Bay City	62,974	647	3,570	67,191	$126,294
Beaver (Hecla No. 1)	Beaver Coal Co. (Hecla Portland Cement & Coal Co.)	Bay City	20,000	....	....	20,000	37,000
Michigan	Michigan Coal Co	Bay City	7,420	7,353	1,725	16,498	33,750
No. 5	Robert Gage Coal Co	Bay City	151,841	3,011	11,862	166,714	301,838
No. 6	Robert Gage Coal Co	Bay City	106,969	....	4,745	111,714	202,801
United City	United City Coal Mining Co	Bay City	5,110	9,172	1,460	15,742	33,020
What Cheer	What Cheer Coal Mining Co	Bay City	104,352	2,288	6,927	113,567	227,920
Central	Central Coal Mining Co	Saginaw	....	14,166	....	14,166	28,403
Wolverine No. 2	Wolverine Coal Co	Saginaw	87,427	....	....	87,427	167,510
Wolverine No. 3	Wolverine Coal Co	Saginaw	153,451	....	....	153,451	273,757
County total			699,544	36,637	30,289	766,470	$1,432,293
CLINTON COUNTY:	F. L. Reed	Grand Ledge	....	2,000	....	2,000	$5,000
EATON COUNTY:							
Schumaker (Grand Ledge Sewer Pipe Co.)	A. B. Schumaker (American Sewer Pipe Co.)	Grand Ledge (Akron)	....	Out of b	usiness.	....	....
	Allen & Walker	Grand Ledge	....	....	....	....	....
	Grand Ledge Clay Products Co	Grand Ledge	....	100	....	100	$250
	Grand Ledge Coal Co	Grand Ledge	....	....	....	....	....
GENESEE COUNTY:	Burton Coal Mining Co	Flint	....	Not yet in	operation.	....	....
	Genesee Coal Mining Co	Flint	7,500	2,500	7,000	17,000	$33,000
INGHAM COUNTY:	T. W. Jenkins	Williamston	....	1,232	270	1,502	$3,438

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Collery.	Operator.	Office.	Average price per ton.	Average No. of days active.	Average No. of employes.	No. of machines.	Total machine mined coal.c	Total pick mined coal.c
BAY COUNTY:								
Black Diamond	Black Diamond Coal Mining Co	Bay City						
Monitor	Handy Bros. Mining Co	Bay City	$1 92	205	130			
Beaver (Hecla No. 1)	Beaver Coal Co. (Hecla Portland Cement & Coal Co)	Bay City	1 85	200	20			
Michigan	Michigan Coal Co.	Bay City	2 21	208	34			
No. 5	Robert Gage Coal Co.	Bay City	1 85	232	330			
No. 6	Robert Gage Coal Co.	Bay City	1 84	235	200			
United City	United City Coal Mining Co.	Bay City	2 31	215	30			
What Cheer	What Cheer Coal Mining Co.	Bay City	2 14	230	160			
Central	Central Coal Mining Co.	Saginaw	2 00	125	75			
Wolverine No. 2	Wolverine Coal Co.	Saginaw	1 92	205	225			
Wolverine No. 3	Wolverine Coal Co.	Saginaw	1 78	236	350			
County total			$1 87	220	1,554		304,720	416,233
CLINTON COUNTY:	F. L. Reed	Grand Ledge	$2 50	250	4			
EATON COUNTY:								
Schumaker (Grand Ledge Sewer Pipe Co.)	A. B. Schumaker (American Sewer Pipe Co.)	Grand Ledge (Akron)						
	Allen & Walker	Grand Ledge						
	Grand Ledge Clay Products Co.	Grand Ledge	$2 50					a1,737
	Grand Ledge Coal Co	Grand Ledge						
GENESEE COUNTY:								
	Burton Coal Mining Co.	Flint						
	Genesee Coal Mining Co	Flint	$1 96	190	52			13,351
INGHAM COUNTY:	T. W. Jenkins	Williamston	$2 79	220	8			1,607

a Includes Clinton mines.

c Taken from the State Coal Mine Inspectors report for 1910.

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Distribution of total product.				Total value.
			Loaded at mine for shipment.	Sold to local trade and employes.	Used at mine for steam and heat.	Total quantity.	
SAGINAW COUNTY:							
No. 1	Robert Gage Coal Co.	Bay City	...	...	...	...	...
No. 2	Robert Gage Coal Co	Bay City	107,996	...	14,235	122,231	$242,209
No. 3	Robert Gage Coal Co.	Bay City	51,543	302	8,030	59,875	110,137
No. 4	Robert Gage Coal Co.	Bay City	...	...	...	...	...
Barnard	Barnard Coal Co	Saginaw	13,077	...	...	13,077	24,114
Buena Vista	Buena Vista Coal Co	Saginaw	...	22,358	1,000	23,358	40,981
Caledonia No. 2	Caledonia Coal Co., Ltd	Saginaw	...	29,837	3,000	32,837	78,737
	Consumers Coal	Saginaw	25,000	...	...	25,000	48,250
Northern or "Jimtown"	Northern Coal & Transit Co.	Saginaw	60,058	...	...	60,058	111,888
Pere Marquette No. 3	Consolidated Coal Co.	Saginaw	...	Idle in	1910.	...	...
Riverside	Riverside Coal Co	Saginaw	77,678	...	...	77,687	151,101
Saginaw	Saginaw Coal Co	Saginaw	58,408	...	...	58,408	118,276
Shiawassee	Shiawassee Coal Co	Saginaw	93,748	...	...	93,748	177,652
Uncle Henry	Uncle Henry Coal Co.	Saginaw	25,922	...	...	25,922	51,714
Swan Creek	Bliss Coal Co.	Swan Creek	69,960	4,555	...	74,515	134,461
Carbon	Savage & Smith	Bent	...	455	111	566	1,413
County total	...	...	583,399	57,507	26,376	667,282	$1,290,933
SHIAWASSEE COUNTY:							
Peak	Detroit Vitrified Brick Co	Corunna	...	3,000	...	3,000	$6,000
New Haven	New Haven Coal Mining Co.	Owosso	6,000	3,000	1,000	10,000	20,000
County total	...	...	6,000	6,000	1,000	13,000	$26,000
TUSCOLA COUNTY:							
Akron	Handy Bros Mining Co.	Bay City	59,376	3,311	3,740	66,427	$136,892
Small coal banks	...	...	...	...	...	b1,186	$2,965
Grand total	...	...	1,355,819	110,473	68,675	1,534,967	$2,930,771

b Included in county totals above.

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Average price per ton.	Average No. of days active.	Average No. of employes.	No. of machines.	Total machine mined coal.	Total pick mined coal.
SAGINAW COUNTY:								
No. 1	Robert Gage Coal Co.	Bay City						
No. 2	Robert Gage Coal Co.	Bay City	$2 08	225	260			
No. 3	Robert Gage Coal Co.	Bay City	1 93	228	130			
No. 4	Robert Gage Coal Co.	Bay City						
Barnard	Barnard Coal Co.	Saginaw	1 84	69	100			
Buena Vista	Buena Vista Coal Co.	Saginaw	1 83	233	47			
Caledonia No. 2	Caledonia Coal Co., Ltd	Saginaw	2 11	250	80			
	Consumers Coal	Saginaw	1 93	200	60			
Northern, or "Jimtown"	Northern Coal & Transit Co.	Saginaw	1 86	207	175			
Pere Marquette No. 3	Consolidated Coal Co.	Saginaw						
Riverside	Riverside Coal Co	Saginaw	1 95	207	200			
Saginaw	Saginaw Coal Co	Saginaw	2 03	214	160			
Shiawassee	Shiawassee Coal Co	Saginaw	1 90	192	300			
Uncle Henry	Uncle Henry Coal Co.	Saginaw	2 00	252	75			
Swan Creek	Bliss Coal Co.	Swan Creek	1 80	209	150			
Carbon	Savage & Smith	Bent	2 50	205	3			
County total			$1 93	206	1,740		250,782	400,032
SHIAWASSEE COUNTY:								
Peak	Detroit Vitrified Brick Co.	Corunna	$2 00	300	4			
New Haven	New Haven Coal Mining Co.	Owosso	2 00	80	60			
County total			$2 00	94	64			9,371
TUSCOLA COUNTY:								
Akron	Handy Bros. Mining Co	Bay City	$2 10	224	153		15,387	51,041
Small coal banks								
Grand total			$1 91	211	3,575		570,489	893,372

PRODUCTION OF COAL BY COUNTIES, 1899-1910.

	Bay.	Eaton.	Jackson.	Saginaw.	Other counties.
1910	766,470	100	....	667,282	101,215
1909	822,577	558	1,500	859,434	100,623
1908	782,503	2,286	5,539	999,338	45,353
1907	962,574	5,982	5,645	1,047,927	13,730
1906	481,398	18,507	8,658	835,475	2,300
1905	544,154	4,058	9,196	915,803	....
1904	410,634	9,057	16,860	906,289	....
1903	325,021	7,393	23,307	1,011,898	....
1902	248,645	8,800	23,889	670,304	13,400
1901	253,821	4,803	20,288	938,042	24,284
1900	190,814	4,530	23,317	601,112	....
1899	104,588	3,421	21,600	455,607	39,492

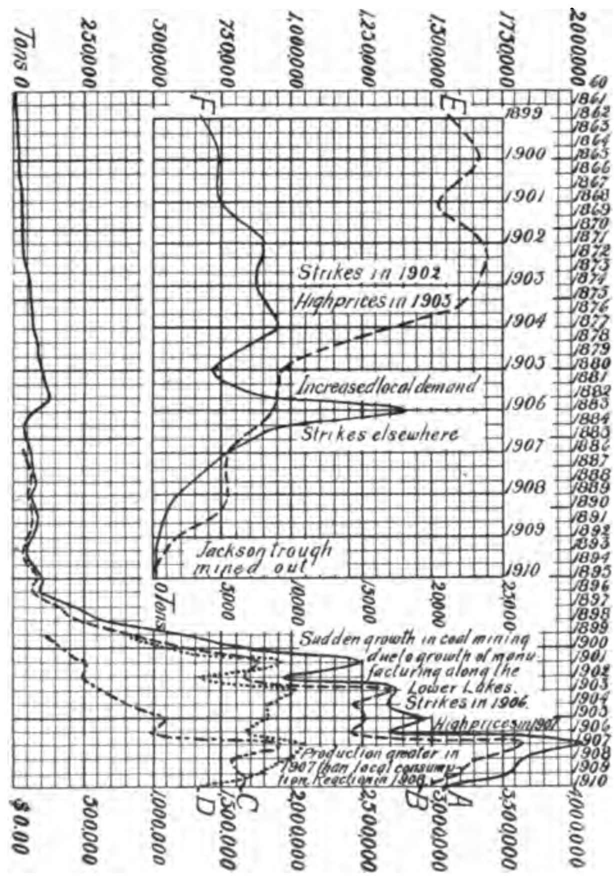

Fig. 13. Graphic representation of the annual production and value of coal in Michigan and by counties, 1860-1910. (Amounts read from the left margins and values on the right.)
A. Curve showing total annual production of coal in Michigan.
B. Total annual value.
C. Total annual production for Saginaw county.
D. Total annual production for Bay county.
E. (See inset) Total annual production for Jackson county, illustrating the decline of the industry in that county.
F. Total annual production for Eaton county, showing effect of strikes upon local production.

GYPSUM AND GYPSUM PRODUCTS.

BY R. A. SMITH.

CONTENTS.

COMPOSITION OF GYPSUM.

Gypsum is a hydrous sulphate of lime, containing one molecule of lime sulphate and two of water. Its chemical formula is thus: $CaSO_4$, $2H_2O$, of which 79.1% is lime sulphate and 20.9% water. Workable deposits of gypsum rarely approach this degree of purity, as they commonly carry impurities of clay, limestone, iron oxide, etc., up to 20%.

Pure gypsum is usually white or translucent, when crystalline. The common fine grained, massive variety of the mine, such as occurs at Alabaster, Michigan, is usually white to reddish gray or even brown. Gypsum is very soft, being easily scratched by the finger nail. It does not effervesce with acids. Heated above a certain temperature, it loses its water of crystallization and becomes a chalky white. Michigan gypsum varies in purity from the almost absolutely pure alabaster to that mixed with clay, shale and limestone.

VARIETIES.

Rock gypsum is the ordinary massive kind. *Alabaster* is the pure fine grained massive rock gypsum used for statuary, etc. The term *selenite* is applied to the translucent crystalline variety, occuring here and there throughout massive deposits. These varieties are characteristic of Michigan gypsum, but the massive variety is by far the most important. The *earthy gypsum, gypsum earth*, or *gypsite,* which occurs in the west, contains earthy material up to 20%. *White sands*, or *gypsum sands,* occur in dunes or heaps in certain western states.

OCCURRENCE AND DISTRIBUTION IN MICHIGAN.

Gypsum occurs usually in beds associated with salt deposits, limestone and shale. Often there are many layers intercalated in the shales and associated rocks. The beds are usually more

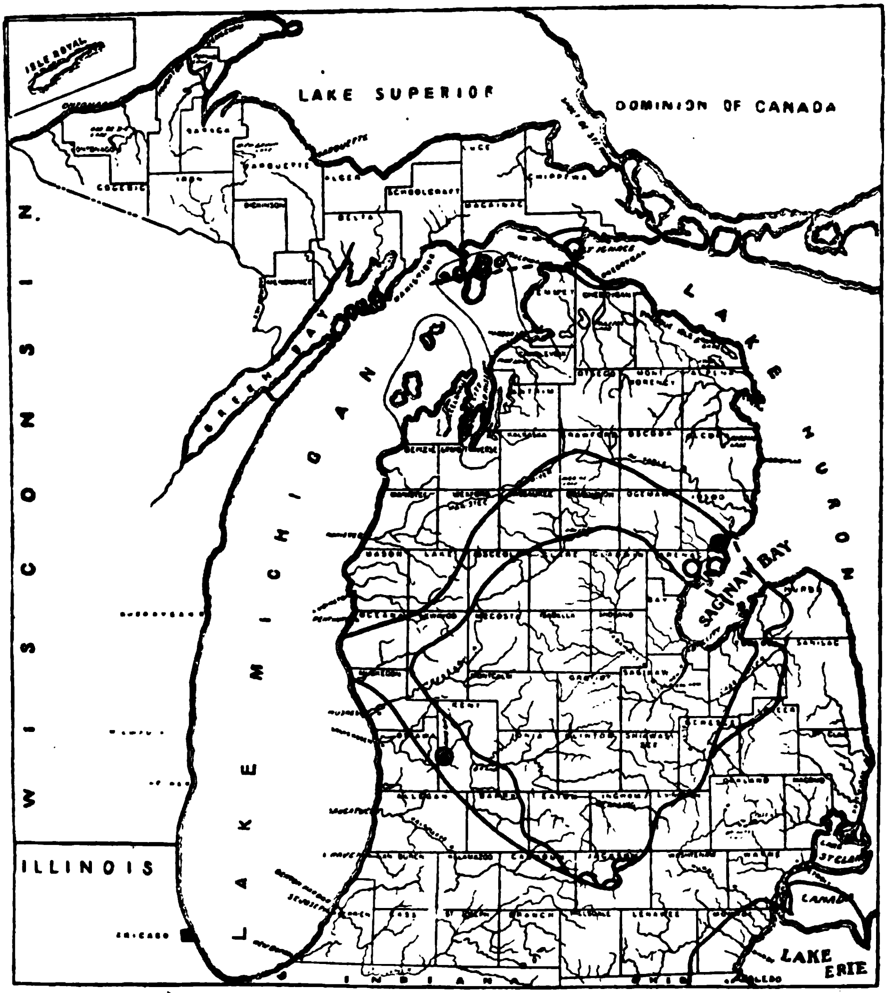

Fig. 14. Sketch map showing location of gypsum producing areas and gypsum deposits.

or less lenticular, thickening and thinning and often pinching out. Sometimes the lentils unite and form one bed. They vary in thickness from a fraction of an inch to 50 feet or more, but usually commercial deposits as in Michigan run from 6 to 25 feet. There are three areas in Michigan where gypsum is mined or is known to occur in deposits of commercial importance; namely, the Grand Rapids-Grandville, the Alabaster or Alabaster-Turner, and the St. Ignace districts. (See figure 14.)

In the Grand Rapids-Grandville district there are usually three workable beds. The first, a 6-foot ledge, is quarried; the second, a 12-foot ledge, is both quarried and mined; and the third, a 22-foot bed, which is some 60 feet below the second, is mined. The upper ledge is often absent from erosion, and the second is sometimes very thin, apparently in some instances from solution. The various beds are overlain and separated mainly by shale, limestones, or sandstones. There are also many other smaller lentils of gypsum intercalated in the associated rocks. They vary in thickness from a few inches to 5 feet or more. The thick lower bed is really composed of two nearly equal beds, separated by a foot of dark shale. Up to 3 or 4 years ago, only the two upper beds had been developed, for it was currently supposed that water would be a serious obstacle to the mining of the deeper beds. Some of the companies, having exhausted their supply of easily accessible gypsum in the surface beds, sunk shafts into the 22-foot bed and found ideal mining conditions, for little or no water was found. At Grandville this lower bed (or another one) was 14 feet thick. From drill records it appears to be continuous and very uniform in thickness and, doubtless, will form the base of extensive mining operations in the future.

At Alabaster, there is quarried a single ledge 18 to 23 feet thick; covered toward Saginaw Bay only by 5 to 8 feet of gravel and toward the west by 9 to 11 feet of boulder clay. Toward the bay, the single thick bed was composed of two layers separated by a layer of hard fossiliferous limestone and shale which has disappeared with the progress of the quarrying to the westward. According to Prof. W. M. Gregory (Arenac county report, 1909), well drillers near Turner and Twining, Arenac county, have discovered the presence of another extensive bed of gypsum. Its depth below surface ranged from about 50 to 100 feet near Turner and Twining to that of an outcrop near the deserted village of Harmon City on Saginaw Bay. Drillers reported thicknesses varying from 6 to 22 feet. This bed, now called the Turner bed, generally lies from 50 to 100 feet or more above the Alabaster. Both beds are very persistent, and, dipping very gently to the southward, they almost certainly have been traced in wells into Bay City and Saginaw.

Prof. Gregory has mapped two probable workable areas, one of which includes the district about Turner and Twining and the other, the region from Harmon City westward several miles. As the drift is rarely less than 30 feet in thickness and sometimes more than a hundred, the Turner bed in most cases will have to be mined instead of quarried.

Beds 5, 13 and 21 feet thick have been reported from the St. Ignace area but their extent and commercial value are unknown. A few miles north of St. Ignace there are deposits which appear to be of probable great value, especially in the region of St. Martins island and Rabbits Back point.

The Salina, or Lower Monroe, formation outcrops in the north Beaver islands and, according to Dr. Lane, there are many indications that the gypsum formation of the St. Ignace area extends westward to these islands, and that gypsum may be found in commercial quantities. Gypsum and anhydrite beds also occur in the Salina in southeastern Michigan, but they are too deep to be of commercial value.

The size of the Grand Rapids area is not well known on account of the depth of the overlying drift to the west and north of the city. Its known area of commercial importance is about 25 square miles, though the gypsum formation extends over a much larger area. The workable area in the Alabaster district proper was formerly estimated at 10 to 15 square miles. But the discovery of the Turner bed to the south in Arenac county has added two more workable areas. Drillings indicate that the Alabaster-Turner district, as it may be called, has a workable area of possibly 30 to 40 square miles out of a total area of 600 square miles of known gypsum formation in eastern Michigan.

The gypsum formation probably extends from Grand Rapids in an arc around to the north and connects with the Alabaster district on the eastern side of Michigan. The Alabaster area doubtless continues under Saginaw Bay into Huron county where gypsum has been found in wells and in the drift. Toward the south, in Tuscola county, the beds die out.

GEOLOGICAL HORIZONS.

The commercially important gypsum deposits occur in the Lower Grand Rapids series of the Upper Carboniferous and in the Monroe formation of the Silurian. The Grand Rapids-Grandville district and the Alabaster-Turner are in the former, and the St. Ignace, in the latter.

ORIGIN.

There are many theories explaining the formation of gypsum deposits such as "Deposition from sulphur springs and volcanic agencies," "Hunt's chemical theory," "Deposition through action of pyrites upon limestone," "Precipitation in rivers," "Alteration of anhydrite to gypsum," and "Gypsum deposited by evaporation in a Mediterranean or closed sea." No one theory is applicable to all deposits, but the theory of deposition in a Mediterranean or closed sea seems most applicable to the larger rock gypsum deposits such as those in Michigan.

If, in an arid climate, an arm of the sea, like the Karaboghay on the eastern side of the Caspian, is separated from the main body of water by a very shallow bar, we have conditions favorable for the deposition of gypsum. Evaporation is very great in the gulf and, as there are no rivers to supply the great loss from evaporation, a constant current flows (3 miles an hour) from the Caspian into the gulf. Conditions are thus like those in a huge evaporating pan with a constant inlet but no outlet. Concentration has already gone on until the amount of contained salts is many times that of the Caspian itself. Continued evaporation will eventually lead to a precipitation of salts as has already occurred in other, though smaller, arms of the Caspian.

In a closed sea, evaporation and consequent concentration would result in a deposition of all the salts. In Salt Lake we have such conditions, beds of salt being laid down during the dry season, muds and silts during the mountain freshets in spring. Thus there is an alteration of muds or sands and salt.

Gypsum is more soluble than limestone but less so than salt, so that, with increasing concentration, we would have limestone, gypsum, and salt deposited in order. Thus gypsum is usually below salt deposits.

The Michigan Sea was a great gulf for most of the time from the Ordovician to the end of the Carboniferous. At times, it approached the conditions of a Mediterranean or even a closed sea. In the Salina or Lower Monroe of the Silurian, conditions favored the deposition of both gypsum and salt. In the Lower Grand Rapids series of the Carboniferous, gypsum, but not salt, was deposited (unless afterwards carried away by solution), the concentration apparently not having been carried to such a degree as that in the Salina.

MANUFACTURE OF CALCINED GYPSUM.

The rock is crushed first in a jaw crusher and then in a pot crusher. Next it goes to a rotary kiln drier, which drives out about 10% of the moisture. After seiving in a rather course trommel to get rid of the coarser material, which is afterwards ground to the proper fineness in a buhr mill, the dry product is boiled in a four-flue kettle, so constructed that the flues carry the heat to the bottom and sides of the kettle and upward to the stack. A shaft propels stirrers below the flues and mixing paddles above, until the boiling expels all of the remaining free moisture. This preliminary boiling must not be above 265° F., or the combined water will begin to separate before the right conditions are obtained for proper calcination. To expel the necessary three-fourths of the water of crystallization, the heat is steadily raised up to a temperature varying from 330° F. to 420° F., but a temperature of 390° F. to 395° F. is more commonly employed. If the boiling is carried on at a temperature above 400° F. nearly all of the combined water will be driven off and the plaster will lose most of its setting properties. Such plaster is said to be "dead burnt" and is used where slow setting is required. When properly boiled, the plaster settles and is drawn off through a gate near the bottom of the kettle. It is then screened through a fine sieve and the coarser residue is ground in a finishing buhr mill.

GYPSUM PRODUCTS.

The numerous varieties of calcined plasters are made by the grinding and partial or complete dehydration of the crude product. There are two general classes of plasters, one partially and the other completely dehydrated.

All plasters burned at a temperature below 400° F. are quick setting, if pure, and may be included under the term *plaster of Paris*. If impure, either naturally or artificially, the plaster sets much more slowly. These are known as *"cement plasters."*

The class of plasters burned above 400° F. are completely dehydrated or "dead burnt." If pure, the gypsum rock produces *flooring plaster*. If certain substances (usually alum of borax) have been added to the pure gypsum, a *hard finish plaster* is the result.

There are various trade names given to special forms of the above plasters. Stucco is almost synonymous with plaster of Paris, though the latter is usually more finely ground. Wall plasters are made by adding hair or wood fibre, as well as retarder, to the calcined plaster. "Board plaster" or plaster-board, widely used because of its convenience, is pressed from plaster interlaminated with thin sheets of cardboard. Hollow blocks and tiles are made from plaster, mixed with suitable fibre, and these, as well as the plaster-board, are used in fire-proofing buildings.

Wall plasters are of two general grades, one a brown or gray coat, and the other a white or a tinted one for finishing. All gypsum wall plasters are commonly mixed with wood fibre or hair filler. These plasters are superior to the old time plasters, but their quick setting qualities makes experience in handling them necessary to get the best results.

Keene's "cement," Parian "cement," etc., belong to the group of dehydrated plasters and are used as hard finishes in buildings. Keene's cement is the base for artificial marble, oramental castings, etc.

Gypsum is also used in calsomines, water paints, and dry colors, such as the Venetian reds. Ordinary paints often contain so much gypsum that it is considered an adulterant.

PRODUCTION.

In the early days, most of the gypsum mined was ground into land plaster. The unlimited supply of gypsum in Michigan soon enabled the producers to more than meet the demand for land plaster. The bulky nature and the low price of the product did not permit shipments for any great distances, so that the producers were forced to turn their attention to the manufacture of the calcined product. With the introduction of the new methods and the flue kilns from New York in 1871, the calcining of gypsum became the more important industry. After 1887 the calcined product always exceeded in amount that of the land plaster which has now become a product of little importance, when compared with the former.

In 1892, the demand for gypsum plasters in the construction of the temporary buildings at the World's Fair at Chicago gave a great impetus to the industry. The wide spread use of such plasters as plaster of Paris, floor, "cement," and wall plaster, has since raised the production of 66,000 tons in 1895 to the high water mark of 394,000 tons in 1909. This was surpassed only by New York which mined 403,000 tons. In 1868 the total production was valued at $165,000, that of 1909 at more than $1,200,000. The total production in 1910 was considerably less, being but 357,000 tons. As the market price in Michigan was slightly lower in 1910, the value was correspondingly less, being only $667,000. New York, on the other hand, increased her production to more than 467,000 tons, valued at about $1,500,000.

Although the World's Fair trade gave a great impetus to the gypsum industry in Michigan, it was not until 1901 that the remarkable growth began. Up to this time, the industry was in the hands of individuals, or separate companies. Competition had kept profits down to such a point that proper equipments for mining and manufacturing were not possible. In 1901, the era of consolidation began with the incorporation of some of the mills with the United States Gypsum Company. The consolidation of interests has continued, until the gypsum industry has been placed upon a sound financial and industrial basis. The mines of the state are now owned or controlled by a few large companies which mine and manufacture with equipments much superior to those possible under the old regime of individual operators. A glance at the table of production (Figure 15) shows that the production of 1900 had been trebled in the short interval of nine years, following the consolidation in 1901.

Most of the crude gypsum mined in Michigan is calcined into the various plasters, such as plaster of Paris, stuccos, wall, floor, and "cement" plasters. Only a few thousand tons was ground into land plaster. A large amount of crude gypsum is sold to cement factories for use in making Portland cement. A smaller amount is sold to paint factories for use as a pigment. Glass factories use large quantities as a flux. The finer grade of the calcined plaster is used for bedding in grinding plate glass. A smaller quantity finds its way into dental cement. The Alabaster variety of gypsum is much used by sculptors and artisans in interior decorations.

Although Michigan has produced more than 5,300,000 tons of gypsum, valued at nearly $16,000,000, its deposits even in the two districts of Grand Rapids-Grandville and Alabaster-Turner have been hardly more than opened up. The full extent of the minable gypsum in these areas is, as yet, unknown. The St. Ignace area has been little prospected, but it has gypsum deposits of very probable great commercial value. With these almost inexhaustible supplies and with the industry already on an established basis, Michigan bids fair, for many years to come, to be one of the leading gypsum producing states in the country.

TABLE SHOWING PRODUCTION OF GYPSUM IN MICHIGAN.

Year.	Ground into land plaster. Tons.	Gypsum calcined into plaster. Tons.	Sold crude. Tons.	Total production. Tons.	Total value.
Before 1868	132,043	14,285		146,328	$671,022
1868	28,837	6,244		35,081	165,298
1869	29,996	7,355		37,351	178,824
1870	31,437	8,246		39,683	191,718
1871	41,126	8,694		49,820	234,054
1872	43,536	10,673		54,209	259,524
1873	44,972	14,724		59,696	297,678
1874	39,126	14,723		53,849	274,284
1875	27,019	10,914		37,933	195,386
1876	39,131	11,498		50,629	248,504
1877	40,000	9,819		49,819	238,550
1878	40,000	8,634		48,634	229,070
1879	43,658	9,070		52,728	247,192
1880	49,570	18,929		68,499	349,710
1881	33,178	20,145		53,323	293,872
1882	37,821	24,136		61,957	344,374
1883	40,082	28,410		68,492	377,567
1884	27,888	27,959		55,847	335,382
1885	28,184	25,281		53,465	286,802
1886	29,373	27,370		56,748	308,094
1887	28,794	30,376		59,170	329,392
1888	22,177	35,125		57,302	347,531
1889	19,823	36,800		56,623	353,869
1890	12,714	47,163	15,000	74,877	192,099
1891	15,100	53,600	11,000	97,700	223,725
1892	14,458	77,599	47,500	139,557	306,527
1893	16,263	77,327	31,000	124,590	303,921
1894	11,982	47,976	20,000	79,958	189,620
1895	9,003	51,028	6,488	66,519	174,007
1896	6,582	60,352	700	67,634	146,424
1897	7,193	71,680	16,001	94,874	193,576
1898	13,345	77,852	1,984	93,181	204,310
1899	17,196	88,315	39,266	144,776	283,537
1900	10,354	86,972	33,328	129,654	285,119
1901	9,808	129,256	46,086	185,150	267,243
1902	13,022	158,320	68,885	240,227	459,621
1903	18,409	198,119	52,565	269,093	700,912
1904	18,294	185,422	34,669	238,385	541,197
1905	20,285	203,313	24,284	247,882	634,434
1906	30,220	208,715	27,517	341,716	753,878
1907	15,500	197,666	36,543	317,261	681,351
1908	11,414	192,403	40,324	327,810	491,928
1909	11,890	344,171	45,781	394,907	1,213,347
1910	7,097	240,905	64,566	357,174	667,199
1911	15,548	206,299	79,050	347,296	523,926
Total	1,184,452	3,402,863	717,253	5,669,317	$16,244 490

See Michigan mining statistics 1891 for further data.

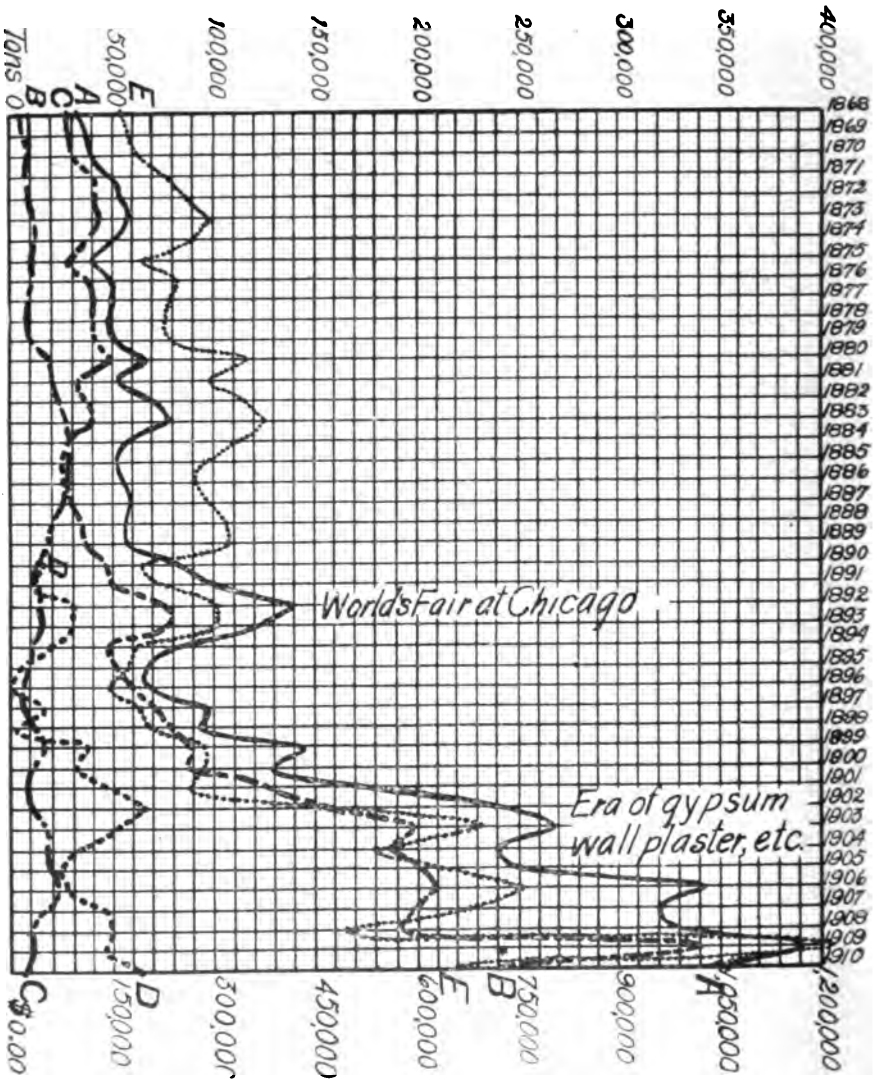

Fig. 15. Graphic representation of the annual production of gypsum, gypsum products, and values, 1868-1910.
A. Total mined.
B. Total calcined into plaster.
C. Total ground into land plaster.
D. Total sold crude to cement and to glass factories, etc.
E. Total value of gypsum and gypsum products.

THE SALT INDUSTRY OF MICHIGAN.

BY C. W. COOK.

CONTENTS.

HISTORICAL.

Two periods of development are to be noted in the salt industry of Michigan; the first covering the time from the admission of Michigan into the Union until 1859, the second, from 1859 to date. The first period was one of governmental initiative and was a complete failure; the second period has been characterized very largely by private initiative and has been as markedly successful as the previous period was the reverse.

By the statehood act of 1836, the state of Michigan was permitted to reserve seventy-two sections of saline lands. Immediately, preparations were made for the selection and development of these lands, among which were areas on the Grand River in Kent county and on the Tittabawassee River in Saginaw county. The sinking of wells was begun at each of these localities but after the expenditure of considerable money both undertakings were abandoned. Next, an attempt was made to lease the lands to individuals on a royalty basis, but this was likewise unsuccessful.

Although the state attempted to stimulate the interest of individuals by offering a bounty on all salt produced within the state, yet the disgraceful action of the state in attempting to evade payment of the bounty, renders the less said of it the better.

The first successful attempt to manufacture salt in Michigan was made by the East Saginaw Salt Manufacturing Co. in 1859. The success of this company led to a rapid development of the industry in the Saginaw Valley where the blocks were operated in connection with sawmills. The industry soon spread to Midland and St. Louis and the lumbering towns on the shores of Lake Huron, such as Caseville, Pt. Crescent, Pt. Austin, New River, Pt. Hope, Harbor Beach, and White Rock on the south side of Saginaw Bay; and Tawas City, East Tawas, Au Sable, and Oscoda to the north.

At first the kettle process was used, slabs and saw-dust being employed for fuel. The rapid development of the industry was however not confined to an increase in the number of blocks but improvements in manufacture soon appeared and the kettle process was forced to give way to the open pan and grainer processes.

That the salt industry was very largely dependent upon lumber is shown by its decline as the timber was used up. All of the lake shore plants have long since disappeared and in some instances such as Pt. Crescent and New River the towns themselves no longer exist. Within the Saginaw Valley itself, the industry is on the wane as is shown by the fact that now there is not one block where formerly there were ten.

Correlative with the decline of the industry in the Saginaw Valley, has been the rise of the Ludington-Manistee district and the region along the Detroit and St. Clair rivers.

As in the case of the Saginaw Valley, the production of salt in the Ludington-Manistee district has been very closely associated with the manufacture of lumber. Only one company, the Anchor Salt Co. of Ludington, is operated independent of the saw-mills. The history of the district also shows that when a company has cut all of its timber the salt block which was operated in connection with the saw-mill has been closed.

From the standpoint of improvements in manufacture, this district has made as rapid strides as it has in increasing its production. It was here that the vacuum pan was first employed in Michigan in the manufacture of salt and it was also the first district to employ the "double effect" and "triple effect" pans. As the last step, there has been installed during the past year a "quadruple pan."

The development of the industry along the St. Clair and Detroit rivers is distinguished from that of the other districts in that its growth has been independent of the lumber industry. This has been possible very largely through the manufacture of table salt, the entire output of which, for the state, comes from this district. Also this district has another advantage in a lower freight rate on coal. One feature of the industry here which has been developed nowhere else in the state is the sinking of a shaft to mine rock salt. The shaft is located at Oakwood in Wayne county and is fully described in the Engineering and Mining Journal for March 18, 1911, pp. 565-569.

RAW MATERIALS.

With the exception of the rocksalt produced at Oakwood, salt is manufactured in Michigan by the evaporation of brines, both natural and artificial. At various times, three different natural brines, each of which is obtained from a sandstone, has been employed. These brine-bearing sandstones are the Parma, the Napoleon, and the Berea.

The Parma brine, while no longer used on account of its being weaker than the underlying Napoleon brine, is characterized by its purity. As may be seen from the analyses in Table 1, it is distinguished from the Napoleon and Berea brines by a higher percentage of calcium sulphate relatively to the earthy chlorides. This brine was one of the first used in Michigan and its utilization was limited to the Saginaw Valley.

TABLE I.

	1.	2.	3.	4.	5.
Calcium sulphate	3.951	....	....	0.129	0.33
Calcium chloride	5.302	41.1	83.00	31.274	110.00
Magnesium chloride	4.115	17.6	31.00	15.675	33.47
Magnesium bromide	....	0.712	1.00	....	....
Ferric oxide and Alumina	....	....	....	....	1.14
Ferrous chloride	....	0.050	Trace.	....	....
Sodium chloride	152.674	167.3	141.00	176.161	186.19
Total solids	166.052	226.675	256.00	232.803	331.73

1, 2, 3, and 4 represents grams per kilogram.

5 represents grams per litre.

1. Parma brine from Gilmore well, Bay City, Michigan. Analysis by Dr. A. C. Goesmann, October, 1862. (Geol. Sur. of Mich. Vol. III, p. 181.)

2 Napoleon brine from Saginaw Salt Co., St. Charles, Michigan. Analysis by J. C. Graves, furnished by O. C. Diehl.

3. Marshall brine from the Dow Chemical Co., Midland, Michigan. Analysis furnished by H. W. Dow.

4. Berea brine from the Ayres well, Pt. Austin, Michigan. (Geol. Sur. of Mich., Vol. III, p. 183.)

5. Berea brine from the North American Chemical Co., Bay City, Michigan. (Geol. Sur. of Mich. report 1905, p. 388.)

The Napoleon brines (Nos. 2 and 3, Table 1) which are the source of the salt of the Saginaw Valley, are characterized by the small percentage of calcium sulphate and the presence of considerable amounts of bromine. It will be noted that the amount of bromine and earthy chlorides increases relatively to the sodium chloride as we go toward the center of the basin. While no analyses are available, Dr. Dow informs me that there is a considerable increase at Mt. Pleasant over Midland.

The Napoleon sandstone is found at a depth of about 650-800 feet at Saginaw, 800 feet at Bay City, 1,300 feet at Midland, and 1,400 feet at Mt. Pleasant.

Besides salt, a number of other products are obtained from this brine. The Dow Chemical Co., of Midland manufactures a large number of chemicals, among which may be mentioned, bromine, bromides, bleaching powder, and chloroform; the Van Schaack Calcium Works of Mt. Pleasant produces bromine and calicum chloride; the Saginaw Plate Glass Co. has recently installed apparatus to recover the calcium chloride from the mother liquors from the salt block; and the North American Chemical Co. of Bay City uses the brine in the preparation of chlorates.

The Berea brine (Nos 4 and 5, Table 1) was used by the plants along the lake shore in Huron and Iosco counties. It contains an appreciable amount of bromine, not shown in the analyses, which was recovered from the bittern at some of the plants.

The artificial brines, employed in the Ludington-Manistee and Detroit-St. Clair rivers districts, are formed by solution of the rock salt of the Salina formation. In the former the flow of ground water in the super-imposed strata is sufficient to form the brine and the pumping is done mostly with compressed air. At most of the plants in the southeastern part of the state, it is necessary to pump water into the wells and the brine when formed is forced up by water pressure.

At Ludington and Manistee the salt layer has a thickness of 20 to 30 feet and is found at a depth of about 1900 feet at Manistee and 2,300 feet at Ludington. It has been thought that but one bed existed in this district.[1] However, the No. 4 well of the Anchor Salt Co. at Ludington shows the presence of four beds, respectively 20, 12, 7, and 5 feet in thickness. The extent of this area is not known, but wells at Frankfort and Muskegon, which should have pierced it had it been present, failed to disclose any salt.

The salt beds of the southeastern area are much greater both in number and thickness, one being over 250 feet thick. In a general way they seem to dip away from the Cincinnati anticline and to increase in thickness along the dip. How far this increase continues we do not know, as no records are available beyond

[1] A. C. Lane, Geol. Sur. Mich., Ann. Rep. for 1908, p. 59.

Royal Oak, where nine beds have an aggregate thickness of 609 feet.

Another area in which rock salt has been found in considerable quantities, but has not, as yet, been exploited, is in the vicinity of Alpena. Five beds of salt with streaks of anhydrite here show an aggregate thickness of over 300 feet.

Although we have no positive evidence on the subject, from a consideration of the general geology of the state and the apparent increase in thickness of the beds along the dip, it seems reasonable to believe that these three areas are but portions of one larger area. Rock salt is therefore likely to be found anywhere within lines joining the outer limits of the different proved areas.

The composition of the brines may be seen from the following analyses:

	1.	2.
Specific gravity	1.138	....
Calcium sulphate	5.66	2.3
Calcium chloride	....	1.0
Magnesium sulphate	....	....
Magnesium chloride	2.015	0.7
Sodium chloride	247.4	265.7
Total solids	255.075	269.7

The above represents grams per kilogram.

1. Filer and Sons, Filer City, Michigan. Analysis by W. and H. Heim, Saginaw, Michigan. Analysis furnished by Mr. E. G. Filer.

2. Michigan Salt Co., Marine City, Michigan. Analysis by Robt. E. Devine, Detroit, Michigan. Analysis furnished by Mr. S. C. McLouth.

EVAPORATING METHODS.

Four different types of apparatus are employed in Michigan for the evaporation of the brines, namely, the open pan, the grainer, the vacuum pan, and the Allsberger system.

The open pan is made of quarter-inch boiler plate iron riveted together to form a shallow pan, 80 to 90 feet long, 18 to 20 feet wide, and about 12 inches deep, with flanging sides bolted to draining boards, which are about three feet wide and inclined toward the pan. The pan is supported on three sides by brick walls, while the fourth side is occupied by the furnace. The two methods of applying the heat are in use. In one, the heat passes from the

A. SALT PLANT OF THE R. G. PETERS SALT AND LUMBER COMPANY.

B. ANCHOR SALT COMPANY PLANT, LUDINGTON, MICHIGAN.

A. GRAINER BLOCK. SAGINAW PLATE GLASS COMPANY, SAGINAW, MICHIGAN.

B. CHEMICAL PLANT. SAGINAW PLATE GLASS COMPANY, SAGINAW, MICHIGAN

furnace at the front to the chimney in the rear; in the other, the space under the pan is partitioned off into three flues. Two of these pass from the furnace to the back of the pan, where they open into the third flue which returns the smoke and heated gases to the chimney, located beside the furnace.

As the evaporation takes place at or near the boiling point, the formation of the salt is very rapid, and it is raked onto the draining boards as fast as formed. This constant removal of salt is necessary not only to prevent its baking, but also because when left it forms a coating which retards the conduction of the heat to the brine and therefore increases the fuel consumption.

The grainer consists of a rectangular vat, 40 to 160 feet long, 8 to 18 feet wide, and 14 to 24 inches deep, near the bottom of which are placed pipes through which steam, either live or exhaust, is conducted. As the water evaporates from the brine, the salt crystalizes out at the surface and then sinks to the bottom of the grainer from which it is either constantly removed by automatic rakers or is allowed to accumulate for twenty-four or forty-eight hours and then removed with shovels. The earlier grainers were constructed of wood. More recently, steel and cement have been employed in their construction.

The vacuum pan consists of a vertical steel cylinder tapering at both ends, in the middle of which is a steam belt, through which the brine tubes pass, with a large tube in the center. A partial vacuum is maintained in the pan so that the boiling point of the brine is considerably lowered. If the pan is run "single effect," the steam formed by the evaporation is taken care of by a condenser. On the other hand, when two or more pans are run in "multiple effect" the steam formed in the first pan is conducted to the belt of the second pan on which a greater vacuum is carried, and is used to furnish the heat for the second pan. The steam from the evaporation in the second pan may be carried to the belt of a third pan and so on. The quadruple effect pan is now in operation in Michigan although in this case the pans differ somewhat from the others in that they are rectangular in shape. The central opening in the steam belt is also rectangular and the brine tubes are inclined. The salt as it forms drops to the bottom of the pan and is removed by a bucket elevator.

The Allsberger system is employed by only one plant. The principle involved is that of preheating the brine under pressure and then running it into pans in which the deposition of the salt takes place without the further addition of heat. The ground plant of the pans resembles a figure eight, with a major diameter of 88 feet and a minor diameter of 44 feet. The depth is 12 inches. In each loop of the pan are revolving arms which sweep the salt into a well in the bottom of one loop from which well the salt is drawn off into a centrifuge and separated from the brine.

Fig. 16. Map showing producing salt districts of Michigan.
Circles represent present producing districts.
Crossed circles represent former producing districts.

INSPECTION AND GRADING.

All salt manufactured in Michigan is subject to state inspection. This inspection is under the supervision of the state salt inspector and his deputies. It is their duty to see that the salt is properly aged, that the weights are correct, and to grade the product, the inspector placing his seal upon each package. The classification of salt used in Michigan is table and dairy, granulated, medium, and packers. Also the salt is graded on the basis of quality into No. 1, and No. 2, these grades applying only to the granulated, medium and packer's. No. 2 grade is any of the above which were intended for No. 1 but have been contaminated in some way so as to show discoloration. The classification into granulated, medium and packer's is on the basis of the size of the particles, the granulated being the finest and the packer's the coarsest. Table and dairy salt are made from either granulated or medium by drying and sizing, either with tubular screens or patent separators. In some instance small amounts of foreign substances are added to certain brands of table salt to prevent caking.

LIST OF COMPANIES.

Buckley and Douglas Lumber Co., Manistee, Mich. Incorporated, December 31, 1892. Edward Buckley, Pres., Treas., and Gen. Mgr.; T. J. Elton, Sec.

The production of salt was begun in August, 1897 at what is now the No. 1 plant. As in the case of all the plants in the Manistee district, salt is manufactured from an artificial brine formed by dissolving the rock salt of the Salina formation. Both the vacuum pan and grainer processes are employed in evaporating the brine which is supplied by four wells, the salt being struck at 1,985 feet. The grainer block contains fifteen cement grainers (12′ x 150′ x 22″) twelve of which produce medium salt and three (using the tail-water from the other grainers) produce packer's salt. The vacuum pan block contains two single effect pans with a diameter of eleven feet. Both exhaust and live steam are used to supply the heat and some coal is employed in addition to the offal from the saw-mill for fuel. The annual capacity of the plant is 672,000 barrels and the storage capacity, 450,000 barrels. 175 men are employed in operating the plant.

The No. 2 plant was formerly the plant of the State Lumber Co., which was taken over by the Buckley and Douglas Co. in the fall of 1910. At this plant, only the grainer process is employed. The evaporation is carried on in seventeen wooden grainers (10.5-12′ x 170′ x 14″) the brine being furnished by three wells ranging in depth from 1,993 to 2,003 feet. The heat used in evaporating the brine is obtained chiefly from exhaust steam from the saw-mill. The annual capacity is 290,000 barrels and the storage capacity, 75,000 barrels. About sixty men are employed.

FILER AND SONS, Filer City, Manistee county, Michigan. Not incorporated. E. G. Filer, Managing partner.

The production of salt by this company was begun in 1888. The salt block contains one B vacuum pan 13 feet in diameter with a daily capacity of 700 barrels. The brine is obtained from one well which reaches the rock salt at a depth of 1,955 feet, the salt bed having a thickness of 31 feet. The evaporation is carried on with exhaust steam from the saw-mill, the output being about 500 barrels per day when operating. The storage capacity is 80,000 barrels and 50 men are employed.

R. G. PETERS SALT AND LUMBER CO., East Lake, Manistee county, Michigan. Incorporated, March 2, 1884. Capital Stock, $1,000,000. R. G. Peters, Pres.; Wm. H. Anderson, Vice-pres; A. W. Farr, Sec.; J. R. Peters, Asst. Sec. and Treas.

This plant which is operated in connection with the saw-mill contains both vacuum pan and grainer blocks. The grainer block contains twenty-one wooden grainers (16′ x 120′ x 22″) with a daily capacity of 4,500 barrels of medium salt. They are operated at about 60% capacity. The vacuum pan block contains three pans, thirty feet in diameter, run "triple effect," with a daily capacity of 3,200 barrels. The vacuum pans are run at about 50% capacity. The brine is furnished by seven wells which reach the rock salt at 1,980 to 1,985 feet. The thickness of the bed varies from 20 to 30 feet in the different wells with a tendency toward the lower value. The storage capacity is 325,000 barrels, and 220 men are employed in operating the plant.

LOUIS SANDS SALT AND LUMBER CO., Manistee, Michigan. Incorporated March 16, 1905. Capital stock, $1,000,000. R. W. Smith, Pres., and Gen. Mgr.; Isabella Sands, 1st Vice-Pres.; Louis M. Sands, 2nd Vice-President.; Geo. M. Clifton, Sec; Geo. M. Burr, Treas.

Two plants are operated by this company, both in connection with saw-mills. The No. 1 plant consists of a grainer block containing fifteen cement grainers (12′ x 150′ x 22″). The brine is furnished by two wells, respectively 2,012 and 2,014 feet in depth. The annual capacity is 200,000 barrels and the storage capacity, 67,000 barrels. About 100 men are employed.

The No. 2 plant (formerly the Rietz plant and the first producer in the district) contains eleven grainers (10′-12′ x 150′ x 20″). The brine is supplied by two wells respectively 1,962 and 1,969 feet in depth. The thickness of the salt in these wells is 32 feet. The annual capacity is 175,000 barrels and the storage capacity, approximately 70,000 barrels.

ANCHOR SALT CO., Ludington, Michigan. Joy Morton, Pres.; Mark Morton, Vice-Pres.; Sterling Morton, Sec.; Daniel Peterkin, Treas.

This company is the only one in the Ludington-Manistee district operating independently of the lumber industry. The vacuum pan process is employed the evaporation being carried on in three pans (18, 19, and 20 feet in diameter), run "triple effect." Live steam is used entirely with coal for fuel. The brine which as in the case of the Manistee district, is formed by the solution of the rock salt of the Salina formation, is supplied by five wells ranging in depth from 2,286 to 2,404 feet. The daily capacity of the plant is 2,000 barrels and the storage capacity, 156,000 barrels. The plant is operated only a portion of the year and employes about sixty men.

STEARNS SALT AND LUMBER CO., Ludington, Michigan. Capital stock, $500,000. J. S. Stearns, Pres.; W. T. Culver, Vice-Pres. and Gen. Mgr.; R. L. Stearns, Sec.-Treas.

The Stearns company operates two plants. The No. 1 plant contains both grainer and vacuum pan blocks. The grainer block consists of nineteen wooden grainers (12′ x 150′ x 22″) with an average daily capacity of 1,000 barrels. The vacuum pan block contains a single effect pan twelve feet in diameter. Exhaust steam is employed in both the grainer and vacuum pan blocks, the steam being obtained from the saw-mill and the Stearns Light and Power Co. The brine is furnished by five wells having a depth of about 2,300 feet. The storage capacity is 167,000 barrels. Eighty men are employed.

At the No. 1 plant an experimental quadruple effect vacuum pan of the Fallar type has been installed by the Rapid Evaporator Co., Detroit, Michigan, for the operation of which the Stearns company furnishes the brine and steam.

The No. 2 plant which is leased from the Cartier Lumber Co., contains six wooden grainers (12′ x 150′ x 22″). There are no wells connected with this plant, the brine being furnished by the No. 1 plant. The daily capacity is 400 barrels and the storage capacity, about 20,000 barrels. Twenty men are employed.

NORTH AMERICAN CHEMICAL CO., Bay City, Michigan. Capital stock, $1,000,000. John Brock, Pres.; W. L. Davies, Gen. Mgr.

A grainer block and a vacuum pan block are operated by this company to utilize the exhaust steam from the chemical works. The grainer block contains eight wooden grainers (11′ x 144′ x 22″) and the vacuum pan block contains two twelve-foot single effect pans. The brine which is the natural brine of the Napoleon sandstone, is furnished by twenty-five wells having an average depth of 950 feet. About thirty-five men are employed.

MERSHON, BACON AND CO., Bay City, Michigan. Capital stock, $50,000. A. W. Bacon, Pres.; E. C. Mershon, Vice-Pres.; W. B. Mershon, Sec.-Treas.

This company operates a small grainer block in connection with their saw-mill. It consists of four wooden grainers (12′ x 145′ x 18″) with a daily capacity of about 90 barrels of packer's salt. The Napoleon brine is employed and is supplied by three wells having a depth of approximately 1,000 feet. Five men are employed in the salt block.

THEO. HIME & CO., Bay City, Michigan.

This company operates in connection with a planing mill, a small salt block containing two wooden grainers, (12′ x 150′ x 18″). The brine (Napoleon) is furnished by one well. The capacity of the block is about 50 barrels per day and four men are employed.

SAGINAW PLATE GLASS CO., Saginaw, Michigan. Incorporated, December, 1909. W. J. Wicks, Pres.; A. D. Eddy, Vice-Pres.; Geo. C. Eastwood, Sec.-Treas.

The salt block of this company contains twelve grainers (12′ x 150′ x 18″ sloping to 21″). Exhaust steam from the glass works is used to evaporate the brine which is that of the Napoleon sandstone and which is supplied by ten wells ranging in depth from 893 to 917 feet. A chemical plant for recovering the calcium chloride from the mother liquors was recently installed. The daily capacity is about 1,000 barrels, both medium and packer's salt being manufactured. Fifteen men are employed.

BRAND AND HARDIN MILLING CO., Saginaw, Michigan. Incorporated, June 16, 1908. Capital stock, $50,000. J. F. Brand, Pres.; C. H. Brand, Vice-Pres.; W. E. DeWitt, Sec.-Treas.

The salt block of this company is the only one in the Saginaw Valley which is not operated in connection with some other industry. It contains two wooden grainers (10′ x 120′ x 22″) with a daily capacity of 100 barrels. The brine is supplied by one well having a depth of about 800 feet. Live steam is used to evaporate the brine and the salt is removed from the grainers by hand. Six men are employed in operating the plant.

BLISS AND VAN AUKEN (Arron P. Bliss and W. G. Van Auken), Saginaw, Michigan.

This company operates, in connection with their saw-mill, a small salt block containing two wooden grainers (10′ x 170′ x 18″) with a daily capacity of 100 barrels. The brine is supplied by four wells ranging depth from 800 to 1,008 feet, and exhaust steam from the saw-mill is used in evaporating the brine. The storage capacity is 12,000 barrels. Six men are employed.

E. GERMAIN, Saginaw, Michigan.

The salt block of E. Germain is operated in connection with a planing mill and a piano factory from which the exhaust steam used in evaporating the brine is obtained. There are four grainers (12′ x 150′ x 22″) the brine for which is furnished by two wells 725 feet in depth. The daily capacity is about 100 barrels and the storage capacity, 8,400 barrels. Six men are employed.

MERSHON, EDDY, PARKER, Co., Saginaw, Michigan. Re-incorporated, February, 1909. Capital stock, $500,000. F. E. Parker, Pres.; C. A. Eddy, Vice-Pres.; A. H Hempstead, Sec.-Treas.

The plant of this company which is located in Carrollton Township, is operated in connection with the planing mill, box factory, etc., of the same company. The salt block contains four wooden grainers (10′ x 112′ x 18″) with a daily capacity of 150 barrels. The brine is furnished by two wells with a depth of about 700 feet. The storage capacity of the plant is 5,500 barrels and five men are employed in operating the block.

S. L. EASTMAN FLOORING Co., Saginaw, Michigan. Incorporated, January 1, 1904. Capital stock, $80,000. S. L. Eastman, Pres. and Treas.; W. H. Erwin, Sec.

The salt block of this company is located in Carrollton Township and contains four wooden grainers (8′ x 110′ x 18″) with a daily capacity of 100 barrels. The brine is supplied by two wells, 740 feet in depth, the evaporation being carried on by exhaust steam from the flooring mill. Six men are employed.

SAGINAW SALT Co., Offices, Bay City, Plant, St. Charles, Michigan. Capital stock, $50,000. Chas. Coryell, Pres.; F. T. Woodworth, Vice-Pres.; F. W. Urch, Sec.-Treas.

This company has two blocks located at the shafts of the Robt. Gage Coal Co., from which exhaust steam for evaporating the brine is obtained. Each block contains five wooden grainers (12′ x 160′ x 30″) with a daily capacity of 150 barrels. The brine, that of the Napoleon sandstone, is furnished by two wells at each block. The wells have a depth of about 800 feet. The storage capacity at each plant is 20,000 barrels. Formerly bromine was recovered from the bittern. This practice has been discontinued, however, for the present.

PETER VAN SCHAACK AND SONS, Offices, 140 Lake St., Chicago, Ill.; Plant, Mt. Pleasant, Michigan.

A small amount of salt is produced by this concern as a by-product in the manufacture of calcium chloride and bromine.

Port Huron Salt Co., Offices, 717 Ry. Exchange Bldg., Chicago, Ill.; Plant, Port Huron, Michigan. Incorporated, January, 1900. Joy Morton, Pres.; Mark Morton, Vice-Pres.; Sterling Morton, Sec.; Daniel Peterkin, Treas.; Otto Huette, Gen. Mgr.

Two plants are operated by this company. The No. 1 plant is located at Port Huron and contains both a grainer and a vacuum pan block in addition to which the plant has apparatus for the manufacture of table salt. The grainer block contains nine grainers, five 18 feet wide and four 14 feet wide. The vacuum pan block contains one twelve-foot pan. Live steam supplied by fourteen Wicks boilers is employed in evaporating the brine which is obtained by dissolving the rocksalt of the Salina formation through the medium of eight wells. The wells have a depth of about 2,200 feet although the first salt bed is encountered between 1,500 and 1,600 feet. The annual production is about 400,000 barrels of which approximately one-half is table salt. The daily capacity is 3,000 barrels and the number of men employed is two hundred.

The Number 2 plant is located at St. Clair and was formerly operated by Thomson Bros. It is an open pan block containing five English direct heat pans (three, 18′ x 77′ and two, 18′ x 87′). The brine is furnished by one well, about 1,700 feet in depth. Coal is used for fuel and about 40 men are employed in operating the plant.

Diamond Crystal Salt Co., St. Clair, Michigan. Capital stock, $650,000. C. F. Moore, Pres.; P. R. Moore, Vice-Pres; F. Moore, Sec.-Treas.; H. Whiting, Gen. Mgr.

Three different processes, the vacuum pan, grainer, and the Allsberger, are employed by this company. The chief process is the Allsberger and the block contains five pans (44′ x 88′ x 12″). The grainer block contains six steel grainers and the vacuum pan block, one six-foot vacuum pan. Live steam, supplied by sixteen Wicks boilers, is used in evaporating the brine which is furnished by seven wells, ranging in depth from 1,630 to 2,200 feet. The daily capacity is 2,850 barrels. At present, the plant is operated at about fifty per cent capacity and about eighty per cent of the output is turned into table and dairy salt. 200 men are employed.

Crystal Flake Salt Co., Ltd., Plant, Marine City, Michigan; Offices, Minneapolis, Minnesota, J. E. Vebleu, Pres.

The plant operated by this company contains six cement grainers (12′ x 128′ x 22″). Live steam is employed in evaporating the brine which is furnished by one well, 1,675 feet in depth. The average daily output is 45 tons of medium and 2.5 tons of packer's salt. The storage capacity is 1,600 tons and the number of employes, eight.

Davidson and Wonsey, Marine City, Michigan. Capital stock, $60,000. Jas. Davidson, Pres.; C. L. Doyle, Vice-Pres.; Palmer Davidson, Sec.-Treas.

The company operates a vacuum pan block containing two-single-effect pans, 12 feet in diameter. Live steam for the evaporation of the brine is furnished by five Marine boilers. The brine is supplied by two wells, respectively 1,750 and 1,900 feet in depth. The daily capacity is 140 tons and the storage capacity, 6,000 tons. Forty men are employed.

Michigan Salt Works, Marine City, Michigan. Re-incorporated, 1903. Capital stock, $100,000. Wm. A. Hazard, Pres.; Edwin J. O'Byran, Vice-Pres.; Sidney C. McLouth, Sec.-Treas.

The salt block is located about two miles south of Marine City and contains eight grainers, as follows: Two cement grainers (18′ x 164′ x 22″), two steel V-grainers (18′ x 100′ x 6′), one wood and three cement grainers (12′ x 120′ x 22″). Steam for evaporating the brine is furnished by five Marine boilers. The brine is supplied by two wells, respectively 1,630 and 1,851 feet in depth. The daily capacity is 800 barrels about twenty per cent of the output being turned into tablesalt. The storage capacity is 60,000 barrels and the number of employes seventy-five.

Delray Salt Co., Delray, Michigan. Incorporated, 1901. Capital stock $100,000. N. W. Clayton, Pres.; A. A. Nelson, Sec.-Treas.; Jos. P. Tracy, Gen. Mgr.

This company operates both grainer and vacuum pan blocks and also manufactures table salt. The grainer block contains six cement grainers (16′ x 160′ x 22″) and the vacuum pan block, three pans (respectively 9, 10, and 11 feet in diameter) run "triple effect." Live steam furnished by three 335 H. P. boiler is used in evaporating the brine supplied by two wells. The daily capacity is 2,000 barrels and the storage capacity 100,000 barrels. Fifty men are employed.

Worcester Salt Co., Ecorse, Michigan. Main offices, 168 Duane St., New York City, N. Y., Lorenzo Burdict, Pres. and Sec.

Both grainer and vacuum pan blocks are operated by this company. The grainer block contains eight iron grainers (12′ x 140′ x 22″) and the vacuum pan block three ten-foot pans, two of which are run "double effect" and the third "single effect." Steam is furnished by six boilers and the brine is supplied by two wells, about 1,525 feet in depth. The company owns a third well but the derrick is down. The daily capacity is 2,500 barrels and table salt constitutes about forty per cent of the output. Fifty men are employed.

PENNSYLVANIA SALT MANUFACTURING Co., Offices, 115 Chestnut St., Philadelphia, Pa.; Plant, Wyandotte, Michigan. Capital stock, $10,000,000. Theo. Armstrong, Pres.; Austin Purvis, Vice-Pres.; J. T. Lee, Sec.; Arthur E. Rice, Treas.

Salt is manufactured by this company only as a by-product in the manufacture of caustic and bleach, the exhaust steam from the chemical plant being employed to evaporate the brine. One twenty-foot single effect vacuum pan is operated with a daily capacity of 200 tons.

DETROIT SALT Co., Offices, 1102-4 Penobscot Bldg., Detroit, Michigan; Plant, Oakwood, Michigan. John M. Mulkey, Pres.; A. E. Jennings, Sec.; Owen W. Mulkey, Treas. Receiver appointed, March, 1911.

This company operates a pan block containing six open pans with a daily capacity of 1,000 barrels. The heat is applied directly to the pans and coal is used as fuel. The brine is supplied by three wells. About one-third of the output is table salt. The storage capacity is 30,000 barrels and 125 men are employed.

The salt shaft at Oakwood was also sunk by this company. The depth of the shaft is 1,060 feet, the thickness of the salt bed at that point being twenty feet. For a complete description of the shaft and surface equipment the reader is referred to the Engineering and Mining Journal, March 18, 1911.

MORTON SALT Co., Offices 717 Ry. Exchange Bldg., Chicago, Ill.: Plant, Wyandotte, Mich. Joy Morton, Pres.; Mark Morton, Vice-Pres.; Sterling Morton, Sec.; Daniel Peterkin, Treas.

This company owns a grainer plant containing five wooden grainers. The steam is supplied by twelve 150 H. P. boilers and the brine by four wells. The plant has not been operated for several years.

PENINSULAR SALT Co., Offices, Detroit, Mich.; Plant, Ecorse, Mich.

The plant of this company was open pan affair. It has not been operated for several years and is in such state of repair that it is doubtful if it will ever be operated again.

WOLTON SALT ASSOCIATION, Pearl Beach, St. Clair Co., Mich.

Operations were never satisfactory and were suspended several years ago.

PRODUCTION.

The development of the salt industry in Michigan was so rapid, that, in 1876, after only sixteen years of production, the state became the leading producer of salt in the United States. This position it held until 1893, when New York reassumed first place. Since 1893, the leadership has vacillated between New York and Michigan, New York holding it during the years 1893-1900, 1902, 1910; and Michigan, during the years 1901, and 1905-09.

The annual production of salt in Michigan, from the foundation of the industry to 1911, as reported by the state salt inspector is given in Table I, column 3. Since these figures represent inspection rather than actual production, they are only approximate. In column 4, the figures, as given in Mineral Resources, U. S. G. S., are shown. From 1893 on, these statistics were obtained directly from the manufactures and therefore represent the true annual production. They also include the salt in the brine used in the manufacture of soda ash, etc., or what is known as "brine salt." While this salt is not produced in the solid form, yet it should properly be considered as part of the saline wealth of the state. The large discrepancy between the production as given by the state salt inspector and that given by the United States Geological Survey is due very largely to the inclusion of the "brine salt" by the latter.

Column 2 represents the total production of the United States, and column 4, Michigan's percentage of the total, based on data given by the United States Geological Survey. From this it will be seen that, since 1880, Michigan has never produced much less than one-quarter, with a number of years approaching one-half, and an average of nearly two-fifths of the entire production.

The table shows, that with one or two exceptions, the growth of the industry in Michigan was steady up to 1887. Then for a period of about six years the production remained practically stationary. This was probably due to the drop in prices and also to the increased competition from new districts. The big decrease of nearly one million barrels, in 1893, is more apparent than real and was due to a change in method of obtaining statistics. The decrease recorded in the inspection for 1804 was undoubtedly due to the tariff act of 1894, which placed salt on the free list. The competition of the imported salt with that of the eastern producers forced the eastern salt to seek a new outlet which brought it into closer competition with the western salt. By the tariff act of 1897, a duty was again placed on salt. The results of this act are reflected in the increased production of 1898, as shown by the increased inspection. The still greater increase recorded by the United States Geological Survey was due to the development of the soda ash industry in Wayne county. The sudden and enormous decrease of over three million barrels, in 1903, was due in part to the closing down of a large number of plants, as a result of the great drop in the market price the year previous, which resulted in a decrease in

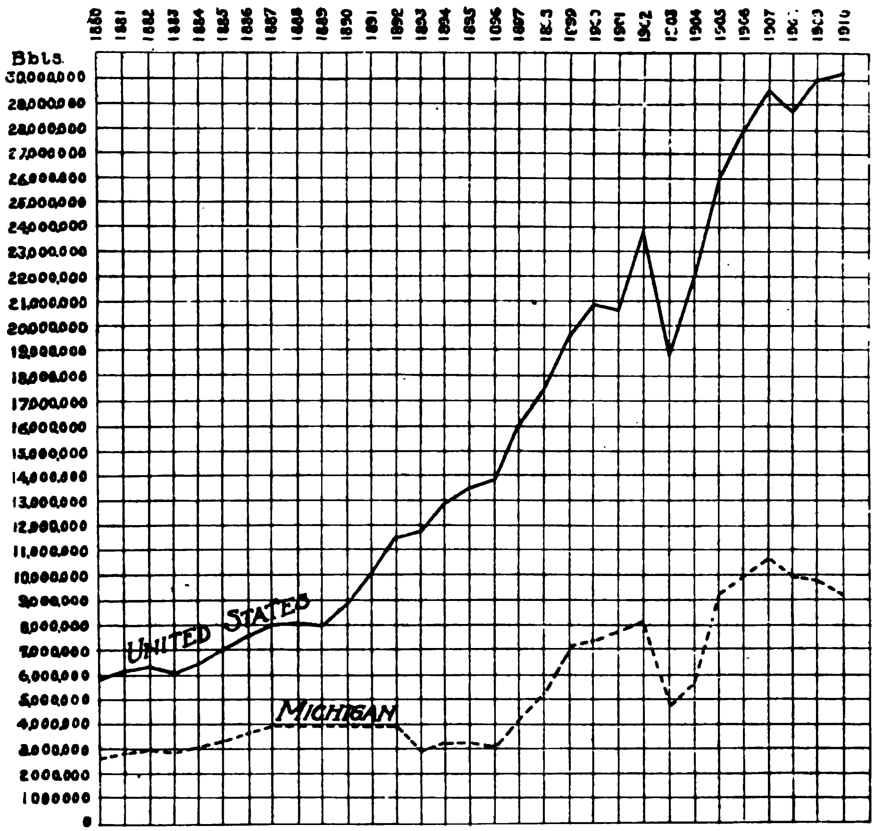

Fig. 17. Production curve for salt in Michigan and the United States.

manufacture of nearly a million barrels. The balance represents the decrease in brine salt. Although there was a decreased inspection in 1909, the salt inspectors report shows that there was an increase in production of over four hundred thousand barrels, in spite of the fact that a number of plants were closed either the whole or part of the year. However in 1910, with a decreased inspection of 450,000 barrels there was a decreased production of approximately 1,100,000 barrels. The fluctuations in the Michigan production and their influence upon the United States production may be best seen from Fig. 17 in which the production curves for both Michigan and the United States are given.

TABLE I.

Year.	U. S. production.	Michigan production.		Per cent of total.	Value.	Price.
		State Salt Inspectors.	U. S. G. S.			
1860		4,000				
1861		125,000				
1862		243,000				
1863		466,000				
1864		529,073				
1865		477,200				
1866		407,997			$734,395	$1.80
1867		474,721			840,255	1.77
1868		555,690			1,028,027	1.85
1869		561,288			786,835	1.58
1870		621,352			820,185	1.32
1871		728,175			1,063,135	1.46
1872		724,481			1,057,742	1.46
1873		821,346			1,127,984	1.37
1874		1,026,970			1,220,094	1.19
1875		1,081,856			1,190,042	1.10
1876		1,482,729			1,556,865	1.05
1877		1,660,997			1,411,847	0.85
1878		1,855,884			1,577,501	0.85
1879		2,058,040			2,099,200	1.02
1880	5,961,060	2,676,588	2,485,177	41.69	2,271,931	0.75
1881	6,200,000	2,750,299		44.35	2,418,171	0.85
1882	6,412,373	3,037,317	3,037,317	47.36	2,126,122	0.70
1883	6,192,231	2,894,672	3,894,672	46.74	2,344,684	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	2,392,648	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	2,967,663	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	2,426,989	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	2,291,842	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	2,261,743	0.585
1889	8,005,565	3,846,979	3,856,929	48.17	2,088,909	0.541
1890	8,776,991	3,838,637	3,838,632	43.72	2,302,579	0.600
1891	9,987,945	3,927,671	3,966,748	39.52	2,037,289	0.513
1892	11,698,890	3,812,504	3,829,478	32.81	2,046,963	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	888,837	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	1,243,619	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	1,048,251	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	718,408	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	1,243,619	0.313
1898	17,612,634	4,171,916	5,263,564	29.88	1,628,081	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2,205,924	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2,033,731	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	2,437,677	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	1,535,823	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	1,119,984	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	1,579,206	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1,851,332	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	2,018,760	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	2,231,129	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	2,458,303	0.241
1909	30,107,646	6,055,661	9,966,744		2,732,556	0.274
1910	30,305,656	5,597,276	9,452,022		2,231,262	0.236

The annual inspection of salt, since the adoption of the state inspection law, according to grades is given in Tables II and III. Previous to 1898, table salt was included under "fine." The figures given under "Table" in Table III include all fancy grades.

TABLE II.

Year.	Fine.	Packers.	Solar.	Second quality.	Common coarse.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1869	513,989	12,918	15,264	19,117	....
1870	568,326	17,869	15,507	19,650	....
1871	655,923	14,677	37,675	19,930	....
1872	672,034	11,110	21,461	19,876	....
1873	746,762	23,671	32,267	20,706	....
1874	960,757	20,090	29,391	16,741	....
1875	1,027,886	10,233	24,336	19,410	....
1876	1,402,410	14,233	24,418	21,668	....
1877	1,590,841	20,389	22,949	26,818	....
1878	1,770,361	19,367	33,541	36,615	....
1879	1,997,350	15,641	18,020	27,029	....
1880	2,598,037	16,691	22,237	48,623	....
1881	2,673,910	13,885	9,683	52,821	....
1882	2,928,542	17,208	31,335	60,222	....
1883	2,828,987	15,424	16,735	33,526	....
1884	3,087,033	19,308	16,957	38,508	....
1885	3,230,646	15,480	19,849	31,428	....
1886	3,548,731	22,221	31,177	71,235	3,893
1887	3,819,738	19,385	13,903	73,905	17,378
1888	3,720,319	18,126	26,174	87,694	13,915
1889	3,721,099	19,780	17,617	93,455	4,987
1890	3,655,331	20,337	18,986	143,068	....
1891	3,764,108	11,400	17,335	121,269	13,559
1892	....	....	....	....	....
1893	3,421,607	16,550	11,893	64,435	....
1894	3,072,241	14,944	7,744	44,012	....
1895	3,421,796	15,350	39,907	52,309	....
1986	3,262,699	14,895	28,869	29,779	....
1897	3,568,833	13,973	5,644	34,314	....

TABLE III.

Year.	Medium.	Granulated.	Packers.	Solar.	Table.	Second quality.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1898	2,702,312	1,199,553	14,649	....	198,002	43,178
1899	2,706,430	1,744,961	29,892	17,353	189,107	44,922
1900	2,789,982	1,680,614	26,759	24,238	162,590	53,902
1901	3,361,616	1,895,093	39,490	11,523	188,068	84,311
1902	3,065,417	1,604,180	71,858	....	219,016	133,774
1903	2,601,932	1,459,029	92,316	8,571	281,514	44,600
1904	3,120,647	1,775,148	95,424	12,535	360,533	35,525
1905	....	....	....	....	....	....
1906	2,977,518	1,988,759	120,658	7,200	520,313	30,111
1907	3,230,561	2,227,137	137,567	7,414	655,436	39,140
1908	3,309,365	2,192,486	119,454	....	575,681	50,770
1909	2,871,274	2,354,035	118,184	....	650,138	62,030
1910	2,702,372	1,910,680	112,561	....	779,756	91,907
1911	....	....	....	....	....	....

The Value of the Product. The total value of the product and the average net price per barrel are given in columns 6 and 7 of Table I. Previous to 1880, the value has been calculated from the average price given by the United States Geological Survey; and from that time to date the price has been determined from the total value. It should be pointed out that the values given for 1893 and the following date, the cost of the package is included. This not only explains the apparently great drop in price in 1893 but also gives fictitious values for the preceding years.

If we allow twenty cents as the cost of the barrel (this is probably below the present cost), we see that the price per barrel has decreased from $1.55 in 1868 to $0.244. It should be kept in mind that the above figures are the average for all grades. Table IV gives the production for 1906-10, classified as to grades with the corresponding values. From this table, it will be apparent, that while table and dairy salt have commanded, for 1910, an average price of $.708 per barrel, brine salt was worth but $0.051; common fine, $0.331; common coarse, $0.349; and packer's, $0.475 per barrel.

TABLE IV.[2]

Year.	Table and dairy.		Common fine.		Common coarse.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906....	509,905	$362,368	2,927,478	$757,470	2,021,287	$618,727
1907....	657,509	392,641	3,601,270	914,154	1,743,840	471,378
1908....	584,452	620,647	3,454,062	968,617	2,020,956	610,286
1909....	585,370	732,907	3,530,303	1,125,095	2,103,719	647,878
1910....	798,434	565,653	2,216,181	734,828	1,992,465	596,301

Year.	Packers.		Brine and other.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906....	91,098	$33,733	4,387,043	$246,462	9,936,802	$2,018,760
1907....	119,459	48,455	4,664,552	235,729	10,786,630	2,062,357
1908....	134,726	53,669	3,991,083	205,084	10,194,270	2,458,303
1909....	93,357	3,983	3,648,395	185,051	9,966,744	2,732,556
1910....	92,426	43,942	4,104,934	211,317	9,452,022	2,231,262

[2]Compiled from mineral resources, U. S. G. S.

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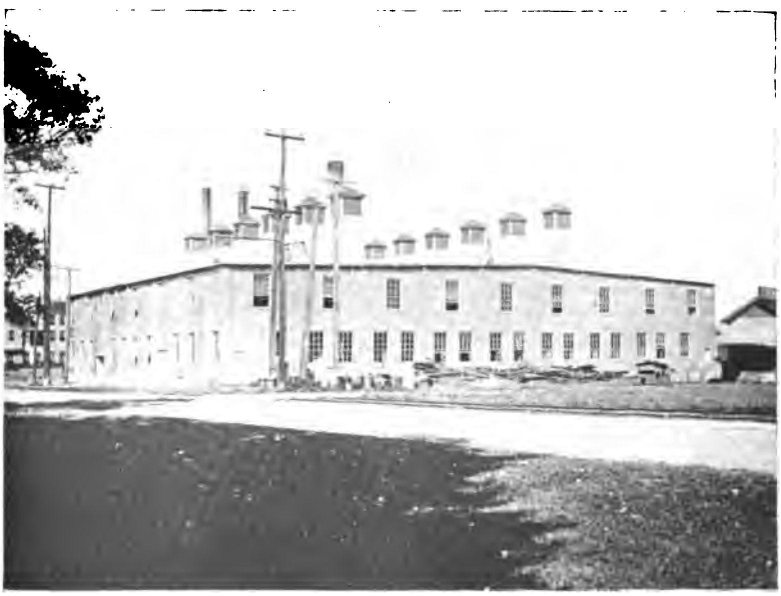
A. PLANT OF THE DIAMOND CRYSTAL SALT COMPANY, ST. CLAIR, MICHIGAN.



B. GRAINER BLOCK. DIAMOND CRYSTAL SALT COMPANY, ST. CLAIR, MICHIGAN.

A. PLANT OF THE DELRAY SALT COMPANY, DELRAY, MICHIGAN.

B. PLANT OF THE DETROIT SALT COMPANY, OAKWOOD, MICHIGAN.

MICHIGAN CEMENT.

BY C. W. COOK.

CONTENTS.

HISTORICAL.

As early as 1878, a vertical kiln plant was erected for the manufacture of cement near Kalamazoo. The venture was, however, a financial failure on account of the high cost of production, and the plant was abandoned in 1882.

No further attempt was made to manufacture cement in Michigan until the organization of the Peerless Portland Cement Co., at Union City, Branch Co., August 23, 1896. The original mill erected by the company was a vertical kiln plant, which was replaced in 1902 by a modern rotary kiln mill (Plate XX, A.). The following year, the Bronson Portland Cement Co., erected a mill at Bronson in Branch Co. In 1898, the Coldwater Portland Cement Co., the forerunner of the Wolverine Portland Cement Co., was organized and mills were erected, first, at Coldwater, and, later, at Quincy.

The years 1899-1901 may be called the "boom years" of the cement industry in Michigan. During these three years, no less than twenty different companies were organized for the manufacture of cement from marl. The plans laid out by some of them were very elaborate but the realization of their hopes was obtained in few, if any, instances. But ten of the twenty ever reached the stage of production and of these five are no longer in operation. Since the "boom days," a number of companies have been projected. Only three of them, however, have become realities.

As far as construction is concerned, the present year (1911) has been marked by the installation of a modern rotary kiln mill by the Michigan Portland Cement Co., replacing the old vertical kiln plant of the Millen (formerly the White) Portland Cement Co. at Chelsea. These kilns are the largest in the state being nine feet in diameter and one hundred and twenty-five feet long. They are expected to have a daily capacity of twelve hundred barrels.

CLASSIFICATION OF CEMENTS.

On the basis of raw materials, cement may be classified as Pozzuolan, natural, and Portland cements.

Pozzuolan cements are produced from a mixture of slaked lime and material containing silica and alumina. The chief sources of the silica and alumina are volcanic ash and blast furnace slag. In this country, the latter is the more important. However, there are no plants in Michigan manufacturing this type of cement.

Natural cements are manufactured by burning impure limestones containing aluminous silicates, without altering the proportions of the ingredients in the rock. Natural cements, therefore, have an indefinite and varying composition. No cements of this class are manufactured in Michigan.

Portland cements, the only class of cements, manufactured in Michigan, are made by burning an artificial mixture containing lime (CaO), silica (SiO_2), and alumina (Al_2O_3) as the essential ingredients, small amounts of ferric oxide (Fe_2O_3), magnesia (MgO), and sulphuric anhydride (SO_3) usually being present as impurities. The composition of the mixture may be seen from the following analyses, which represent actual mixtures ready for burning.[1]

ANALYSES OF PORTLAND CEMENT MIXTURES.

	1.	2.	3.	4.
Silica (SiO_2)	12.85	12.92	13.52	14.94
Alumina (Al_2O_3)	4.92	4.83	6.56	2.66
Iron oxide (Fe_2O_3)	1.21	1.77	....	1.10
Lime carbonate ($CaCO_3$)	76.36	75.53	75.13	75.59
Magnesium carb. ($MgCO_3$)	2.13	4.34	4.32	4.64
Total	97.47	99.39	99.53	98.93

When alkalis and sulphates are present, they should not exceed three per cent, and five to six per cent is considered the upper limit of permissible magnesium carbonate. The proportions of silica to alumina and ferric oxide should lie between the limits expressed by the following formulae:

$$\frac{SiO_2}{Al_2O_3 + Fe_2O_3} \triangleright 2 \text{ and } \frac{SiO_2}{Al_2O_3 + Fe_2O_3} \triangleleft 3.5$$

RAW MATERIALS.

In Michigan, the lime is derived from limestone and marl, while clay and shale are employed as the source of the silica and alumina. Limestone and marl, as is also the case with clay and shale, differ from one another principally in their state of aggregation, their composition being essentially the same.

Although a number of limestones outcrop beneath the drift in the southern peninsula of Michigan, not all of them are suitable for the manufacture of Portland cement. As already stated a cement limestone should be low in magnesia and sulphur and only three of the Michigan limestones answer these requirements, namely, certain layers of the Traverse and Dundee formations, and of the Michigan series. Their composition is shown by the following analyses.[2]

[1]U. S. Geological Sur. Min. Res. 1907, Part II, p. 483.
[2]For other analyses see I. C. Russell, The Portland Cement Industry in Michigan, U. S. G. S. Ann. Rpt., Pt. II, pp. 641-646; also David J. Hale and others, Geol. Sur. Mich. Vol. VIII, Pt. III; also, W. H. Sherzer, Geol. Sur. Mich., Vol. VII, Pt. I; also E. C. Eckel, U. S. G. S., Bul. 243, pp. 196-205.

ANALYSES OF MICHIGAN LIMESTONES.

	1.[3]	2.[4]	3.[5]	4.[6]
Silica	1.14	0.33	0.60	....
Calcium carbonate	96.91	98.37	95.24	96.00
Magnesium carbonate	1.40	0.92	1.00	1.00
Iron oxide	....	....	....	....
Alumina	0.31	0.18	3.04	0.50
Organic matter	0.02	....	....	....
Moisture	0.05	....	....	....
Undetermined	0.17	....	....	1.40
Total	100.00	99.96	99.88	99.00

[3]Traverse limestone, Onaway Limestone Co., Onaway, Mich.
[4]Same, Alpena Portland Cement Co., Alpena, Mich., U. S. G. S. 22nd Ann. Rpt.
[5]Nine foot bed, Dundee, Bellevue, Wayne Co., Mich. U. S. G. S. 22nd Ann. Rpt.
[6]Michigan series, Bellevue, Eaton Co., Mich. Geol. Sur. Mich. Vol. VIII Pt. III.

Fig. 18. Map showing cement plants in Michigan, 1911.
Circles represent plants operating in 1911.
Crossed circles represent plants not operating in 1911.

Of the above named limestones, only the Traverse and Michigan are, at present quarried for the manufacture of cement,—the former at Alpena and Petoskey, and the latter at Bellevue, Eaton Co.

The other prominent series of limestones in Michigan, the Monroe series,[7] is generally high in magnesia and therefore unfitted for use in the manufacture of cement.

It should be remembered that, for the most part, the limestones of Michigan outcrop underneath a covering of glacial drift of varying thickness. Therefore, in considering the exploitation of the various beds, it is essential to examine not only the composition of the limestone but also the thickness of the overburden. In addition to which, the economic factors resulting from location should also receive due consideration.

Marl[8] is a surface deposit formed in lakes and swamps, and consists of calcium carbonate in a finely divided state of aggregation, so that when wet it appears as a mud. However, when dried, a certain amount of cementation occurs, producing a loosely aggregated, friable mass. The marl is apt to be contaminated with organic matter and is therefore, generally, although not necessarily, less pure than the limestone.

The composition of various marls is shown by the following analyses:[9]

The distribution of marl beds of varying quality within the southern peninsula of Michigan is rather wide-spread, no less than twenty-two counties being known to contain beds of workable size

ANALYSES OF MICHIGAN MARLS.

	1.[10]	2.[11]	3.[12]	4.[13]	5.[14]
Silica	1.13	0.48	0.52	0.20	0.22
Alumina	0.44 (Alumina and Ferric oxide)	0.17	0.51	0.50	0.76 (Alumina and Ferric oxide)
Ferric oxide		0.51	0.53	0.60	
Calcium carbonate	91.29	93.25	92.25	89.50	92.07
Magnesium carbonate	4.58	3.88	2.87	1.74	2.63
Sulphuric anhydride	Trace.	0.55	0.89	0.58	....
Volatile less CO_2 to satisfy CaO and MgO	1.90	....	....	4.32	....
Total	99.34	98.84	97.57	97.44	95.68

[7]For analyses, see W. H. Sherzer, Geol. Sur. Mich., Vol. VII, Pt. I.
[8]For a more complete discussion of marl see the papers by Russell and Hale, already cited.
[9]For additional analyses, see references on limestone.
[10]Egyptian Portland Cement Co., Fenton, Mich. Analysis by C. W. Cook.
[11]Aetna Portland Cement Co., Fenton, Mich. Analysis by E. D. Campbell, U. S. G. S., 22nd Ann. Rept., Pt. III, p. 650.
[12]Wolverine Portland Cement Co., Coldwater, Mich. Analysis by E. D. Campbell, U. S. G. S., 22nd Ann. Rpt., Pt. III, p. 650.
[13]Omega Portland Cement Co., Mosherville, Mich. Analysis by E. D. Campbell, U. S. G. S., 22nd Ann. Rpt. Pt. III, p. 651.
[14]Peninsular Portland Cement Co., Cement City, Mich. Analysis recalculated from analysis given in Geol. Sur. Mich. Vol. VIII, Pt. III, p. 236.

with a total area of over 26,000 acres, however, on account of impurities, economic considerations, etc. Not all of these beds are available for the manufacture of cement.

As in the case of limestone, there are a number of shales which outcrop in Michigan. Three of them have, thus far, been employed in the manufacture of cement,—namely, the Traverse, at Alpena, the Coldwater at Newaygo, Coldwater, and Quincy, and the Michigan at Bellevue. The composition of these shales is shown by the following analyses by H. Ries.[15]

ANALYSES OF MICHIGAN SHALES.

	1.[16]	2.[17]	3.[18]	4.[19]	5.[20]
Silica	58.70	65.60	62.10	53.44	61.09
Alumina	25.95	19.31	20.09	24.80	19.19
Ferric oxide	....	5.89	7.81	....	6.78
Calcium oxide	1.00	0.56	0.65	0.71	2.51
Magnesium oxide	0.74	....	0.96	0.25	0.65
Alkalies	5.54	5.98	....	....	3.16
Water } Carbon dioxide }	8.07	9.47	7.90	20.75	5.13
Sulphuric anhydride	....	....	0.49	....	1.42

Of the other shales, the Antrim and those of the Saginaw formation may be mentioned. The Antrim shale is characterized by a high percentage of silica relatively to the alumina and ferric oxide and also by a high percentage of organic matter, as is shown by the following analysis by W. H. Johnson:[21]

ANALYSES OF ANTRIM SHALE.

Volatile matter	17.96
Fixed carbon	6.49
Ash	75.55
Total	100.00

ANALYSES OF ASH.

Silica	70.54
Alumina	15.33
Ferric oxide	5.31
Calcium oxide	2.38
Magnesium oxide	0.78
Alkalies, etc., by difference	5.56
Total	100.00

[15] U. S. G. S., Prof. Paper, No. 11 and Geol. Sur. Mich., Vol. VIII, Pt. I.
[16] Michigan Series, Grand Rapids, Mich., Geol. Sur. Mich., Vol. VII, Pt. I, p. 40.
[17] Michigan series, Grand Rapids, Mich., ibid, p. 41.
[18] Coldwater shale, Bronson, Mich., ibid, p. 41.
[19] Coldwater Shale, Coldwater, Mich., ibid, p. 43.
[20] Traverse shale, Alpena, Mich., ibid, p. 48.
[21] U. S. G. S., 22nd Ann. Rpt., Pt. III, p. 668.

The shales of the Saginaw formation on the other hand are relatively low in silica. The following analyses are given by Russell:[22]

ANALYSES OF THE SHALES OF THE SAGINAW FORMATION.

	1.	2.	3.	4.	5.	6.
Silica	54.50	52.45	57.10	61.13	54.93	41.38
Alumina	30.75	23.27	20.02	26.90	31.43	27.02
Ferric oxide	3.50	7.93	8.18			
Calcium oxide	1.05	....	....	0.96	0.22	0.52
Calcium carbonate	....	1.82	0.71	....	....	....
Magnesium oxide	1.69	....	....	0.96	1.58	0.90
Magnesium carbonate	....	1.06	1.47	....	....	....
Sodium oxide	0.80	4.37	2.76	?	?	?
Potassium oxide	2.20			?	?	?
Water and organic matter	5.51	9.10	9.76	6.47	7.44	23.11
Total	100.00	100.00	100.00	96.58	95.60	92.93

Although surface clays formed during the Pleistocene period of glaciation are widely distributed over the southern peninsula of Michigan, they are for the most part not especially satisfactory for use in the manufacture of cement. For that reason, a number of the mills in the southern part of the state import their clay from Ohio. The only Pleistocene clays of Michigan which are being used at present in the manufacture of cement occur near Corunna, Shiawassee Co., and Gray village, Washtenaw Co. The former is utilized by the New Aetna Portland Cement Co., Fenton, Mich., and the latter by the Michigan Portland Cement Co. A more complete discussion of this subject may be found in the papers by Ries, Hale, and Russell already cited.

LIST OF MILLS.[23]

Burt Portland Cement Co., Bellevue, Eaton Co., Mich. W. R. Burt, Pres.; Geo. R. Burt, Treas. and Gen. Mgr.

The dry process is employed, the raw materials being limestone and shale of the Michigan series. The shale occurs underneath the limestone and the two are mixed in quarrying, the proper mixture being obtained before burning by combining the mixture from different bins. The burning is done in rotary kilns of which there are eight (6.5′ x 60′) with a daily capacity of 1,500 barrels.

Huron Portland Cement Co., Alpena, Mich. Offices 1525 Ford Bldg., Detroit, Mich. Incorporated, January 26, 1907. Capital stock, preferred, $800,000; common $1,200,000. J. B. Ford, Pres.; E. L. Ford, Vice-Pres.; S. T. Crapo, Sec. and Treas.

[22] Ibid, p. 670.
[23] For location of the various plants see Fig. 18.

The dry process is used, limestone and shale being employed as the raw materials. The limestone is that of the Traverse formation and is obtained from the quarry of the Michigan Alkali Co., Alpena. The shale, also of Traverse age, is quarried on the company's lands in Sec. 30, T. 31 N., R. 7 E. The mill contains six rotary kilns (8′ x 110′) with a daily capacity of 3,000 barrels. In as much as the mill is located on the shore of Thunder Bay, the company enjoys the advantage of water transportation for its fuel and also the finished product.

MICHIGAN PORTLAND CEMENT CO., Gray Village, Washtenaw Co., Mich. Plate XX, B.) Incorporated June 14, 1911. Capital stock, preferred $100,000, common, $400,000. N. S. Potter, Pres.; N. S. Potter, Jr., Vice-Pres. and Gen. Mgr.; C. Z. Potter, Sec.; K. L. Potter, Treas.

This company, which took over the property and vertical kiln plant of the Millen (formerly the White) Portland Cement Co., has constructed a rotary kiln plant. There are three kilns (8′ x 125′) with a daily capacity of 1,200 barrels. The wet process is employed with marl and clay as the raw materials. Both the clay and marl are obtained from lands near the plant.

NEW AETNA PORTLAND CEMENT CO., Fenton, Mich. Offices, 50 Congress St., Boston, Mass., and 412 Union Trust Bldg., Detroit, Mich. Reincorporated under the laws of Maine, June, 1907. F. R. Johnson, Pres.; R. E. Payne, Sec. and Treas.; O. J. Lingermann, Gen. Mgr.

The mill of this company, which is the successor to the Detroit Portland Cement Co., and the Aetna Portland Cement Co., is located on the shores of Mud Lake, two miles west of Fenton, Genesee Co. The wet process is employed with marl and clay as the raw materials. The marl is obtained from Mud Lake and the clay is shipped in from Corunna, Shiawassee Co. The mill contains eight rotary kilns (6′ x 60′) with a daily capacity of 1,000 barrels.

NEWAYGO PORTLAND CEMENT CO.,[24] Newaygo, Newaygo Co., Mich. Incorporated May 12, 1899; reincorporated June 16, 1911. Capital stock, $500,000. D. McCool, Pres.; Wilder D. Stevens, Vice-Pres.; Clay H. Hollister, Sec. and Treas.; W. A. Ansorge, Asst. Sec. and Treas.

This company employs the wet process with limestone and shale as the raw materials. The plant was originally designed to manufacture cement from marl but the marl was found unsatisfactory

[24] The name has recently been changed to the Grand Rapids Portland Cement Co. with offices at Grand Rapids. Cement and Engineering News, October, 1911.

and limestone was substituted. The Traverse limestone and the Coldwater shales, which are used, are purchased from the Petoskey Crushed Stone Co., the limestone quarries of which are located in Secs. 2 and 3, T. 34 N., R. 6 W., while the shale beds are in Sec. 26, T. 32 N., R. 8 W. The burning is done in rotary kilns of which there are eleven (1-6′ x 60′ and 10-6′ x 90′) with a daily capacity of 2,000 barrels. The plant is operated by electricity generated by water power from the Muskegon river.

Omega Portland Cement Co., Mosherville, Hillsdale Co., Mich. Incorporated February 18, 1899. Capital stock, $300,000. Bonds, $20,000. F. M. Stewart, Pres.; Walter Sawyer, Vice-Pres.; H. J. Tubbs, Sec.; Amos Kendall, Treas. and Gen. Mgr.

The wet process is employed with marl and clay as the raw materials. The marl is obtained from Cobb's Lake on the shores of which the plant is located. The clay is shipped in from Ohio. The mill contains five rotary kilns (6′ x 60′) with a daily capacity of 500 barrels.

Peerless Portland Cement Co., Union City, Branch Co., Mich. Incorporated August 19, 1897; reincorporated March 22, 1906. Capital stock, preferred, $350,000, common, $500,000, bonds, $350,000. A. W. Wright, Pres.; S. O. Bush, Vice-Pres.; Wm. M. Hatch, Sec. and Treas.; J. R. Patterson, Gen. Mgr.

The plant employs the wet process with marl and shale as the raw materials. The marl is shipped in on the Michigan Central Railroad from Spring Arbor, T. 3 S., R. 2 W. The burning is done in nine rotary kilns (5.5′ and 6.5′ x 70′) with a daily capacity of 1,350 barrels.

Peninsular Portland Cement Co., Offices, Cooley Blk., Jackson; mill at Cement City, Lenawee Co., Mich. Incorporated June, 1899. Capital stock, preferred, $700,000; common, $593,000. Wm. F. Cowhan, Pres.; D. C. Griffin, Vice-Pres.; J. W. Shove, Sec.; N. S. Potter, Treas.

The wet process is employed with clay and marl as the raw materials. The marl is obtained from Goose Lake and the clay comes from Bryan, Ohio. The burning is done in nine rotary kilns (3-7′ x 80′ and 6-6′ x 60′) with a daily capacity of 1,250 barrels.

Wolverine Portland Cement Co., Offices, Coldwater, Michigan; mills, Coldwater and Quincy, Michigan. Incorporated February, 1902. Capital stock, $1,000,000. L. M. Wing, Pres. and Gen. Mgr.; C. T. Jones, Vice-Pres.; E. R. Root, Sec. and Treas.

This company operates two mills, one at Coldwater, (Plate XXI A.) and one at Quincy, (Plate XXI B.). The wet process is employed at both points with marl and shale as the raw materials. The marl is obtained from lakes near the plant and the shale, the Coldwater, is quarried about an half mile from the Coldwater plant. The Coldwater plant contains fourteen kilns (6′ x 60′) and the Quincy mill seven kilns (6′ x 120′), each having a daily capacity of 1,500 barrels. 150 men are employed at the Coldwater plant and 120 at the Quincy plant.

WYANDOTTE PORTLAND CEMENT CO., Offices, 1525 Ford Bldg., Detroit; plant, Wyandotte, Michigan. Incorporated, November 21, 1903. Capital stock, $1,000. S. T. Crapo, Pres. and Treas.; J. B. Ford, Vice-Pres.; H. J. Paxton, Sec. and Gen. Mgr.

Both wet and dry processes are employed, limestone and clay being used as the raw materials. The limestone is furnished by the Michigan Alkali Co., a portion being dry and a portion pulverized and wet. The clay is obtained from Millbury, Ohio. The burning is done in three rotary kilns (7′ x 100′) with a daily capacity of 1,000 barrels. 110 men are employed.

In addition to the above named plants, the following non-producing plants may be mentioned.

ALPENA PORTLAND CEMENT CO., Alpena, Mich. Organized, August 9, 1899. Capital stock, $500,000. Future operation doubtful.

EGYPTIAN PORTLAND CEMENT CO., Fenton, Mich. Incorporated, June 30, 1900. Capital stock, $1,050,000; bonds, $650,000. Reincorporated. Capital stock, preferred A, $35,000; preferred B, $500,000; common, $1,050,000; bonds, $200,000. This property has been ordered sold by the court. Future operation uncertain.

ELK CEMENT AND LIME CO., Elk Rapids, Mich. Incorporated as the Elk Rapids Portland Cement Co., March 3, 1900. Reincorporated, December 8, 1904. Capital stock, 1st preferred, $50,000; 2nd preferred, $150,000; common, $300,000; bonds, $250,000. F. R. Williams was appointed receiver, January 4, 1911. Future operation is doubtful.

NEW BRONSON PORTLAND CEMENT CO., Bronson, Mich. Reincorporated, April 15, 1910. Capital stock, $110,000. F. M. Rudd, Pres.; J. S. Galloway, Vice-Pres.; C. H. Powley, Sec.; H. F. Mowery, Treas. This company purchased, at the receiver's sale, the plant of the Chamite Cement and Clay Product Co., (successor to the Bronson Portland Cement Co.). The present company has never operated the plant and future operations are doubtful.

THE HECLA CO., (successor to the Hecla Portland Cement Co.), Bay City, Mich. Henry Hertz is receiver of this company and it is very doubtful if the plant will every be operated again.

In Table I is given a list of all mills built or projected, together with the important facts concerning each.

TABLE I.

Name.	Location.	Capital stock and bonds.	Process.	Raw materials.	Fuel.	No. of kilns.	Rated capacity.
Aetna Portland Cement Co	Fenton		Wet	Marl and clay	Coal	8	1,000
Alpena Portland Cement Co	Alpena	500,000	Dry	Limestone and clay	Coal	6	1,000
Bellaire Portland Cement Co	Bellaire						
Burt Portland Cement Co	Bellevue	Not Inc	Dry	Limestone and shale	Coal	8	1,500
Bronson Portland Cement Co	Bronson	500,000	Wet	Marl and shale	Coal	10	1,000
Chamite Cement and Clay Product Co	Bronson		Wet	Marl and shale	Coal	10	1,000
Clare Portland Cement Co	Grant to Clare Co	1,000,000	Wet	Marl and shale			
Coldwater Portland Cement Co	Coldwater	300,000	Wet	Marl and shale	Coal		
Detroit Portland Cement Co	Fenton	1,000,000	Wet	Marl and clay	Coal	8	1,000
Eagle Portland Cement Co	Kalamazoo		Vertical kilns	Marl and clay	Coke	4	100
Egyptian Portland Cement Co	Fenton	1,650,000	Wet	Marl and clay	Coal	9	1,200
Elk Rapids Portland Cement Co	Elk Rapids	500,000	Originally wet	Originally marl and shale; later limestone			
Elk Cement and Lime Co	Elk Rapids	750,000	Dry	Limestone and shale	Coal	5	1,000
El Cajou Portland Cement Co	Alpena						
Farwell Portland Cement Co	Farwell	525,000					
German Portland Cement Co	White Pigeon	300,000	Wet	Marl and clay			
Great Lake Portland Cement Co	Charlevoix						
Great Northern Portland Cement Co	Marlborough	5,000,000	Wet	Marl and clay	Coal		
Hecla Cement and Coal Co	Bay City	5,000,000	Wet	Marl and clay	Coal		
Hecla Portland Cement Co	Bay City		Dry	Limestone and clay	Coal		
Hecla (The) Co	Bay City		Dry	Limestone and clay	Coal	6	
Huron Portland Cement Co	Alpena	2,000,000	Dry	Limestone and shale	Coal	6	3,000
Logan Portland Cement Co	Fenton		Wet	Marl and Clay	Coal		
Lupton Portland Cement Co	Lupton	1,250,000	Wet	Marl and clay	Coal		
Millen Portland Cement Co	Chelsea		Vertical kilns	Marl and clay	Coke		
Michigan Portland Cement Co	Gray Village	500,000	Wet	Marl and clay	Coal	3	1,200
Michigan Portland Cement Co	Coldwater	2,500,000					
Michigan Alkali Co	Wyandotte			Caustic soda refuse and shale			
New Aetna Portland Cement Co	Fenton		Wet	Marl and clay	Coal	8	1,000
New Bronson Portland Cement Co	Bronson	110,000	Wet	Marl and shale	Coal	10	1,000

Name.	Location.	Employes.	Remarks.
Aetna Portland Cement Co	Fenton		Successor to Detroit P. C. Co. See new Aetna Portland Cement Co.
Alpena Portland Cement Co	Alpena		Has not operated in two years.
Bellaire Portland Cement Co	Bellaire		Plant never built.
Burt Portland Cement Co	Bellevue		Began producing September, 1905.
Bronson Portland Cement Co	Bronson		See Chamite and Clay Products Co.
Chamite Cement and Clay Product Co	Bronson		Successor to the Bronson Portland Cement Co. See New Bronson P. C. Co.
Clare Portland Cement Co	Grant to Clare Co		Plant never built.
Coldwater Portland Cement Co	Coldwater		See Michigan Portland Cement Co., Coldwater.
Detroit Portland Cement Co	Fenton		See Aetna Portland Cement Co.
Eagle Portland Cement Co	Kalamazoo		Suspended operations about 1882.
Egyptian Portland Cement Co	Fenton		Plant ordered sold by the courts. No operations for two years.
Elk Rapids Portland Cement Co	Elk Rapids		See Elk Cement and Lime Co.
Elk Cement and Lime Co	Elk Rapids	90	Successor to Elk Rapids Portland Cement Co. Receivers appointed January 4, 1911.
El Cajou Portland Cement Co	Alpena		Never built. Not operating.
Farwell Portland Cement Co	Farwell		Plant never completed.
German Portland Cement Co	White Pigeon		Never progressed beyond the newspaper stage.
Great Lake Portland Cement Co	Charlevoix		
Great Northern Portland Cement Co	Marlborough		Plant dismantled.
Hecla Cement and Coal Co	Bay City		See Hecla Portland Cement Co.
Hecla Portland Cement Co	Bay City		Successor to Hecla Cement and Coal Co. See Hecla (The) Co.
Hecla (The) Co	Bay City		Successor to Hecla Portland Cement Co. In hands of receivers. Future operations doubtful.
Huron Portland Cement Co	Alpena	200	
Logan Portland Cement Co	Fenton		Successor to Twentieth Century Portland Cement Co. Plant never built.
Lupton Portland Cement Co	Lupton		Plant never built.
Millen Portland Cement Co	Chelsea		Successor to White Portland Cement Co. See Michigan Portland Cement Co., Gray Village.
Michigan Portland Cement Co	Gray Village	65	Successor to the Millen Portland Cement Co. Began operations July 13, 1911.
Michigan Portland Cement Co	Coldwater		Successor to the Coldwater Portland Cement Co. See Wolverine Portland Cement Co.
Michigan Alkali Co	Wyandotte		See Wyandotte Portland Cement Co.
New Aetna Portland Cement Co	Fenton	100	Successor to the Aetna Portland Cement Co.
New Bronson Portland Cement Co	Bronson		Successor to the Chamite Cement and Clay Product Co. New company has never operated.

TABLE I.

Name.	Location.	Capital stock and bonds.	Process.	Raw materials.	Fuel.	No. of kilns.	Rated capacity.
Newaygo Portland Cement Co	Newaygo	$500,000	Wet	Limestone and shale	Coal	11	2,000
Omega Portland Cement Co	Mosherville	320,000	Wet	Marl and clay	Coal	5	500
Peerless Portland Cement Co	Union City	1,200,000	Wet	Marl and shale	Coal	9	1,350
Peninsular Portland Cement Co	Cement City	1,293,000	Wet	Marl and clay	Coal	9	1,250
Pyramid Portland Cement Co	Spring Arbor	525,000	Wet	Marl and clay	Coal		
Standard Portland Cement Co	Lakeland	1,000,000	Wet	Marl and clay	Coal		
Standiford Portland Cement Co	Athens		Wet	Marl and clay	Coal		
Three Rivers Portland Cement Co	Three Rivers	20,000	Wet	Marl and clay	Coal		
Toledo Portland Cement Co	Manchester						
Twentieth Century Portland Cement Co	Fenton	750,000	Wet	Marl and clay	Coal		
Wayne Portland Cement Co	Brighton	800,000	Wet	Marl and clay	Coal		
Watervale Portland Cement Co		1,000,000	Wet	Marl and clay	Coal		
West German Portland Cement Co	Lima	1,000,000	Wet	Marl and clay			
White Portland Cement Co	Chelsea		Vertical kilns	Marl and clay	Coke		
Wolverine Portland Cement Co	Coldwater	1,000,000	Wet	Marl and shale	Coal	14	1,500
Wolverine Portland Cement Co	Quincy			Marl and shale	Coal	7	1,500
Wyandotte Portland Cement Co	Wyandotte	1,000	Wet and dry	Limestone and clay	Coal	3	1,000
Zenith Portland Cement Co	Grass Lake	1,000,000	Wet	Marl and clay	Coal		

Name.	Location.	Employes.	Remarks.
Newaygo Portland Cement Co.	Newaygo	120	New company incorporated June 16, 1911. Old capital stock and bonds $3,000,000. Name recently changed to Grand Portland Cement Co.
Omega Portland Cement Co.	Mosherville		
Peerless Portland Cement Co.	Union City	80	Originally a vertical kiln plant.
Peninsular Portland Cement Co	Cement City	135	
Pyramid Portland Cement Co.	Spring Arbor		Plant never built. Marl lands now owned and operated by the Peerless Portland Cement Co.
Standard Portland Cement Co.	Lakeland		Plant never built.
Standiford Portland Cement Co	Athens		Plant never built.
Three Rivers Portland Cement Co	Three Rivers		Plant never built.
Toledo Portland Cement Co.	Manchester		Plant never completed.
Twentieth Century Portland Cement Co	Fenton		Plant never built. See Logan Portland Cement Co.
Wayne Portland Cement Co	Brighton		Plant never built.
Watervale Portland Cement Co.			Plant never built.
West German Portland Cement Co.	Lima		Plant never built.
White Portland Cement Co	Chelsea		See Millen Portland Cement Co.
Wolverine Portland Cement Co.	Coldwater	150	Successor to Michigan Portland Cement Co., Coldwater.
Wolverine Portland Cement Co.	Quincy	120	Successor to Michigan Portland Cement Co., Coldwater.
Wyandotte Portland Cement Co.	Wyandotte	110	Successor to Michigan Alkali Co.
Zenith Portland Cement Co.	Grass Lake		Plant never built.

PRODUCTION.

The annual production of cement in Michigan together with the value of the same from 1896 to 1910 is given in Table II. In column 1, is indicated the number of plants in operation, while column 4 shows the percentage of increase or decrease over the preceding year.

TABLE II.

Year.	No. of plants in operation.	Product, barrels.	Value.	Change per cent.
1896	1	4,000	7,000	....
1897	2	15,000	26,250	275.0
1898	2	77,000	134,750	413.3
1899	4	343,566	513,849	346.2
1900	6	664,750	830,940	93.4
1901	10	1,025,718	1,128,290	54.1
1902	10	1,577,006	2,134,396	53.7
1903	13	1,955,183	2,674,780	23.9
1904	16	2,247,160	2,365,656	14.9
1905	16	2,773,283	2,921,507	23.4
1906	14	3,747,525	4,814,965	35.5
1907	14	3,572,668	4,381,731	4.6[25]
1908	15	2,892,576	2,556,215	19.0[25]
1909	12	3,212,751	2,619,259	11.6
1910	12	3,687,719	3,378,940	11.7

[25]Decrease.

It will be seen that the maximum number of plants in operation was reached in 1904. However, the maximum production was not attained until 1906 when but 14 instead of 16 plants were operating. Following the maximum production of 1906, a decrease is shown for the next two years and, although increases are indicated for 1909 and 1910, the high water mark of 1906 has not been regained.

The figures for the number of plants in operation do not give the exact status of the case as in several instances the closing down of one plant has been offset by the opening of another.

In Table III, the Michigan production is compared with that of the United States. The Michigan production, the United States production, and Michigan's percentage of the same are given in columns 1, 2, and 3. In columns 4, 5, and 6, are indicated the values of the product together with Michigan's percentage.

TABLE III.

Year.	Michigan product.	U. S. product.	Michigan per cent.	Michigan value.	U. S. value.	Michigan per cent.
1896....	4,000	1,543,023	0.25	7,000	2,424,011	0.29
1897....	15,000	2,677,775	0.56	26,250	4,315,891	0.60
1898....	77,000	3,692,284	2.11	134,750	5,970,773	2.3
1899....	343,566	5,652,266	6.1	513,849	8,074,371	6.36
1900....	664,750	8,482,020	7.8	830,990	9,280,525	8.9
1901....	1,025,718	12,711,225	8.0	1,128,290	12,532,360	9.0
1902....	1,577,006	17,230,644	9.1	2,134,396	20,864,078	10.2
1903....	1,955,183	22,342,973	8.7	2,674,780	27,713,319	9.7
1904....	2,247,160	26,505,881	8.5	2,365,656	23,355,119	10.1
1905....	2,773,283	35,246,812	7.9	2,921,507	33,245,867	8.7
1906....	3,747,525	46,463,424	8.06	4,814,965	52,466,186	9.2
1907....	3,572,668	48,785,390	7.3	4,384,731	53,992,551	8.1
1908....	2,892,576	51,072,612	5.6	2,556,215	43,547,679	5.8
1909....	3,212,751	64,991,431	4.9	2,619,259	52,858,354	4.9
1910....	3,687,719	76,549,951	4.8	3,378,940	68,205,800	4.9

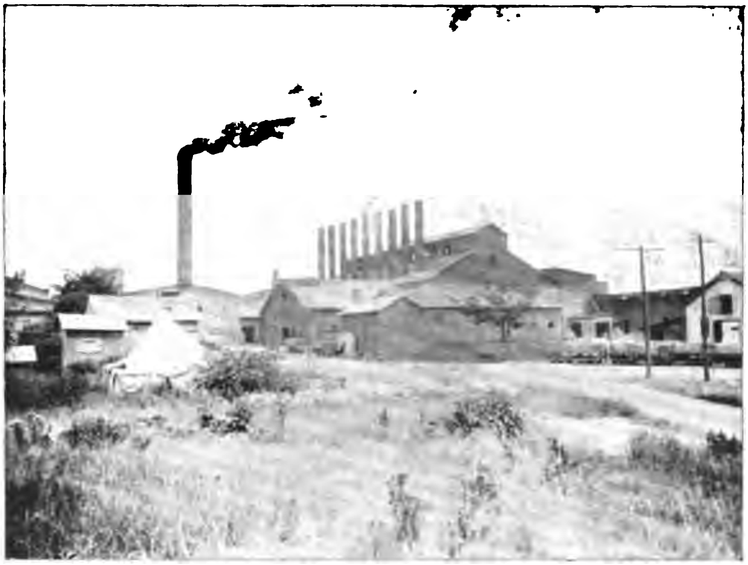
It is to be noted that the percentage of value is generally somewhat higher than the percentage of product indicating that the price received per barrel for Michigan cement has been slightly in advance of the average price for the United States. This is also shown in Table IV which gives the annual price per barrel for Michigan and for the United States.

TABLE IV.

Year.	Price per barrel Michigan.	Price per barrel average U. S.
1896	$1.75	$1.57
1897	1.75	1.61
1898	1.747	1.62
1899	1.492	1.43
1900	1.25	1.09
1901	1.10	0.99
1902	1.353	1.21
1903	1.367	1.24
1904	1.052	0.88
1905	1.053	0.94
1906	1.284	1.13
1907	1.227	1.11
1908	0.883	0.85
1909	0.815	0.813
1910	0.916	0.891

The decrease in the number of plants indicated in Table II is undoubtedly explained by the low price per barrel which the manufactures have received in recent years. That the average price per barrel is not far from the cost of manufacture is shown by the following compilation by Dr. F. M. Chance[26] from the reports of seven companies.

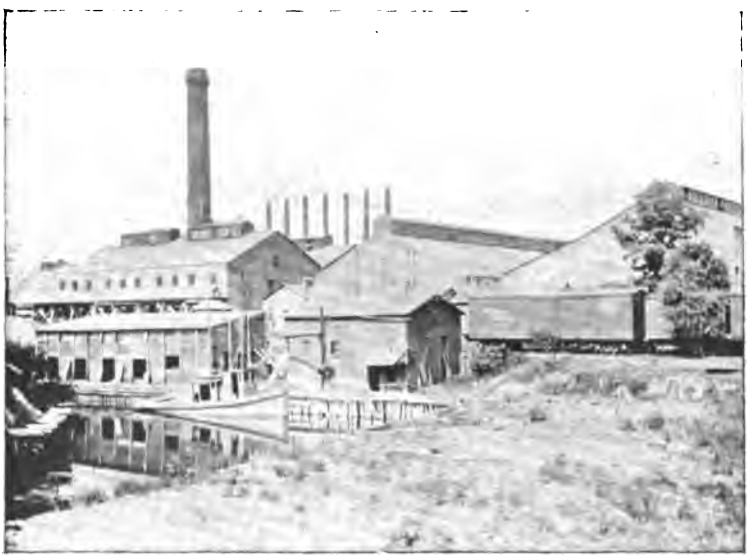
[26]Appraisal of mining properties of Michigan. Lansing, Mich., 1911, p. 79.



A. PLANT OF THE PEERLESS PORTLAND CEMENT COMPANY, UNION CITY, MICHIGAN.

B. PLANT OF THE MICHIGAN PORTLAND CEMENT COMPANY, GRAY VILLAGE, MICHIGAN.

A. PLANT OF THE WOLVERINE PORTLAND CEMENT COMPANY, COLDWATER, MICHIGAN.



B. PLANT OF THE WOLVERINE PORTLAND CEMENT COMPANY, QUINCY, MICHIGAN.

	Output in barrels.	Cost.	Receipts.
1908	1,645,134	$1,469,307	$1,517,608
1909	1,188,197	1,485,794	1,520,081
1910	2,006,266	1,705,924	1,876,035
Total	5,540,597	$4,661,025	$4,913,724
Average of three years per barrel, cents		84.1	88.7

PRESENT OUTLOOK

It cannot be said that the present outlook is by any means promising. While the utilization of cement has increased very rapidly, yet it has by no means kept pace with the increased production.

The Michigan industry finds itself possessed of a very limited market due to its geographical position and the growth of the industry in adjacent states. This has narrowed the field practically to the confines of the state. The result is that such strong competition has been engendered among the Michigan companies that only those companies with exceptionally favorable conditions, such as location near market, cheap transportation, utilization of by-products, freedom from indebtedness, etc., have been able to operate without a loss. In addition to the local competition, the Michigan plants have also had to compete with the mills of other states which have used Michigan as a "dumping ground' for their surplus, while serving a better market, in other directions, from which Michigan is cut off by the high freight rates.

It is difficult to see any immediate relief from the above mentioned conditions. Attempts have been made to secure the reduction of freight rates to certain points but as yet nothing has been accomplished along that line. At present, it appears to be merely a case of survival of the fittest. It is possible that a considerable decrease in the number of producing plants might enable the remaining ones to earn a fair return on their investment.

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GOLD IN MICHIGAN.

BY R. C. ALLEN.

CONTENTS.

GOLD.

Mr. Geo. A. Newett of Ishpeming, formerly Commissioner of Mineral Statistics of Michigan, gives in his report of 1896 an interesting and full account of the discoveries and the mining of gold in Michigan. No gold has been produced in the state since the closing of the Ropes Mine in 1897, except an unknown amount obtained by a reworking of some of the tailings of this mine. In recent years no attempts have been made toward a resumption of operations at the old prospects which were located following and as a result of the Ropes discovery, nor have new gold deposits been searched for.

In this volume it seems proper to introduce in part Mr. Newett's account of gold mining not only for the historical interest which it has but also as a reminder that a resumption of gold mining in this state is a future possibility, vague as it may appear at present. The occurrences of gold ores as described by Mr. Newett are characteristic of the Lake Superior region in general, as are also the unsuccessful attempts at mining them. The ores of the Ropes Mine are native or free gold in a gangue of quartz occurring in veins in peridotite in the Keewatin rocks. The occurrence is not dissimilar in general to those in the Porcupine district of Ontario where success in a large way seems about for the first time to be realized, if attained which will be all the more noteworthy in view of the long list of utter failures and near failures in past years in attempts to mine gold in the Lake Superior region. The following is a quotation of the essential parts of Mr. Newett's account written in 1896 to which reference is made above.

DISCOVERY OF GOLD IN MICHIGAN.

As early as the time in which Dr. Douglass Houghton, Michigan's first State Geologist, was engaged in the task of examining the Upper Peninsula rocks, it was known that gold existed in this portion of the State. Dr. Houghton, upon one of his brief trips from the camp at which he was temporarily located, secured enough gold to fill an eagle's quill. The gold, as remembered by those who saw it, was very coarse, and the doctor said he had obtained it from the bed of a little stream of water. The unfortunate drowning of Dr. Houghton occurred before he had disclosed the secret of the whereabouts of the discovery. Those who accompanied him during his work in the Upper Peninsula are not clear as to the exact place in which the camp was located at the time, and many points have been chosen as the correct one. It is generally believed that the spot was not far from where the most active work has since been done in the way of developing the gold-bearing veins of this region.

In January, 1864, DuBois & Williams, analytical chemists, of Philadelphia, Pa., in assaying specimens of quartz for silver, from the Holyoke silver district, eight miles north of the present city of Ishpeming, were surprised to find gold, the quartz holding it at the rate of several hundred dollars per ton. They reported this, but little attention was given the story, and no searching resulted.

The first discovery that led to anything of practical kind, and the one from which has sprung all that has has been done in the Michigan gold fields, was made by Mr. Julius Ropes, of Ishpeming. This gentleman, a chemist, had noticed the presence of the metal in numerous rock samples he had taken, and he finally located a vein of quartz from which all subsequent excitement has resulted. This was in 1880, and the location was the south half of the northwest quarter of Sec. 29, 48-27, three miles northeast of Ishpeming City. It was in a range of serpentine rocks, and near the edge of a wet swamp. A company was formed, the fee of the mineral having been first been purchased, and here

THE ROPES MINE,

the first gold mine in the State of Michigan, was opened. It was not started on the spot at which the original find was made, but high ground, about 850 feet farther west, was selected, and here a shaft was sunk, a small mill erected, and the first milling work was done 1882. Since then the mill has been increased in size, and at one time 65 heads of Cornish stamps were dropping.

The Ropes was unfortunate in that it lacked sufficient funds to carry on its mining work as it should be done in order to secure the best results. In its earlier history there were many different managers who had charge of the business, and few of them were experienced in the work of milling. Like most gold mines, the Ropes has its peculiarities, and much time and money was expended in becoming familiar with them. About the time the best methods were learned, and the money had been spent, the people grew tired, the few assessments levied having discouraged them. In 1896 they were mining and milling a ton of rock for about $1.85, which was certainly doing remarkably well considering the small amount treated per day, about 65 tons.

The Ropes rock is a hard one to stamp. It contains considerable talcose slate, this being sticky and soft, acting as a cushion under the heads. The rock has to be stamped fine, a 40-mesh screen being used, and the tonnage per head is small as compared to mines where a rock of different nature is met with. With all this understood, the management certainly made an excellent record, and deserved a better financial condition under which to labor.

The Ropes ore formation possesses a width of from 30 to 50 feet, and is made up of talcose slates in which the ore occurs in lenticular form and generally running transversely across the formation. Lenses are found in all imaginable positions, but the general course is as described. These lenses are made up of narrow bands of quartz and slate, and the minerals associated with the gold are galena, iron pyrites, gray and yellow copper ores. Occasionally one sees a speck of free gold, and at several places in the mine small vugs containing considerable free gold were found. At one such place about $400 worth of the native metal was taken. Generally, however, the ore bodies have been of low grade, the average yielding something like $2 or $3 per ton. Could the mine have been opened up differently, and a selecting of the rock made, this average could have been considerably improved.

There is one shaft to the 15th level, a vertical depth of 850 feet. To the 12th level the lode has a slight dip to the south, but from this point to the present lowest level it inclines slightly in the opposite direction, the walls being nearly vertical. The ore lenses have a pitch to the west. The bottom of the first main lens was found at the 5th level, that of the second at the 9th, and in 1896 they were working upon the fourth lens in the bottom levels, the work here being entirely upon the east side of the shaft whereas in the upper levels the stoping was done to the west. In the lens encountered on the 16th level, the slate mixture is almost entirely missing, the vein being almost solid quartz, and giving an average of about $6 per ton, this showing a better and stronger vein than has been found at any other point in the mine. The shaft does not reach to the bottom of this level, but stops at the 15th. An incline shaft was sunk at a distance of 150 feet east of the main shaft to secure the ore of this level. The hoisting was done from this sub-shaft by a small engine. They carried this shaft down until the shape of the new lens was determined. They had an idea that its westward pitch would carry it under the line of the main shaft, in which case the latter would have been continued downward and the lens would have been mined from this avenue. As the pitch of all the ore bodies thus far encountered has been westward, it is fair to argue that the position of this would prove no exception to the others.

The finding of ore of better quality, and in larger body than has heretofore been met with is particularly encouraging on this lowest level. It speaks well for the persistence of the gold, and offers substantial reasons why the Ropes should have been given a better show than was accorded it in the way of money to do business with.

A small territory was worked upon. A length of 550 feet on the trend of the lode embraces it all, and from this there was produced $605,056.95 worth of gold and silver. This is the gross yield, and I give it to show that there is gold in the rock of this mine. This embraces the product from the commencement up to the first of January, 1896. The gold is generally free milling. What concentrates were saved were sent to Aurora, Ill., for treatment. Frue vanners were employed for the concentration. The bulk of the gold is held in the "quick" in the mortars and on the copper plates, the common form of amalgamation being observed.

An advantage the mine has is the solid walls that need no timbering and the freedom from water. In the 16th level not a drop of water came from the level. The vein was stoped out on the overhand plan. The ground was drilled by machines. About 35 men were employed in 1896.

Another point of vantage was the cheapness with which the water supply was secured. The source is the Carp river something more than a mile distant. Here a dam was constructed, and, with a four-foot fall, a pump was operated by a turbine wheel that furnished all the water the mill needed, and the supply is ample for any future demand that may be made under a prosperous condition of things.

At the point where gold was first found by Mr. Ropes on this property, the vein was narrow, but very rich, giving about $200 per ton, by assay. There is the territory lying between this and the shaft at the mine upon which practically nothing has been done in the way of exploration and where there should be something valuable disclosed by practical testing of the ground. The fact that the ore lenses in the mine pitch to the west, and that gold was found on surface so far east, is an encouraging sign.

Several years after mining work was discontinued by the Ropes Gold & Silver Company, Mr. W. H. Rood, of Ishpeming, erected several large vats and attempted to reclaim the gold in the tailings that had been wasted into the low ground immediately north of the mill. The cyanide process was employed, and the work was just fairly started when the death of Mr. Rood put an end to it. Several thousand dollars had been reclaimed and Mr. Rood stated that he was making a profit. Unfortunately, no one took up the cyaniding after this time. The plant was in the nature of an experiment and demonstrated the fact that the tailings could be successfully treated. Had the cyanide plant been operated simultaneously with mining and milling activities it might have enabled the company to secure the margin of profit necessary to success.

The product for 1895 was valued as follows: Gold $34,838.69; silver, $1,373.16; total, $36,211.85.

Two miles and a half west of the Ropes mine, on Sec. 35, town 48, range 28, is

THE MICHIGAN GOLD MINE.

This property has produced some of the finest specimens of free gold ever seen. Many of these yielded gold at the rate of $160,000 per ton. Indeed, so rich were they, that they offered too great a temptation to the miners who were employed there, and the trunk of one enterprising fellow who was all ready to take his departure for Europe was looked into and found to contain over two thousand dollars' worth of golden treasure, secured from this property when the eyes of the bosses were not upon him. How many thousands were stolen is not known, but there probably were many of them. This property was its busiest in 1890, and for a time there was a lively trading in its shares. At a depth of about 80 feet in two shafts that were sunk, the gold had diminished to such a degree as to dishearten those who were conducting the exploration and work was abandoned. A little was done in 1895, but nothing of value accomplished. It consisted principally in making a test of some of the rock already mined.

The Michigan has several veins crossing its lands, and it was upon the largest of these that the work was done, although gold was found in the smaller ones. The veins are in diorite, differing in this respect from the Ropes. Their trend is nearly east and west, and they observe a nearly vertical position. There is little or no silver, and the gold where found is free milling, there being little mineral in the rock aside from the gold. The rock stamps freely, and under the ordinary Cornish head a large amount could be treated daily.

During the months of January, February and March, 1890, the mine produced $12,675.35 worth of bullion, and this was the time when excitement regarding it ran highest. The total yield is valued at $17,699.36. With the great diminished percentage of gold in the bottom of the exploring shafts interest also waned, and all work was finally abandoned, and those who invested in the shares of the company were out the money put in.

The shafts of the Michigan Gold Company were less than 100 feet in depth. What another one hundred feet would have shown can but be conjectured. The property was well equipped with machinery, there were several creditable buildings, and everything was in shape in 1896 to resume work on short notice.

THE GOLD LAKE.

This prospect is immediately west of the Michigan on lands belonging to the Lake Superior Iron Company. The latter company sunk a shaft, and secured many fine specimens, after which they leased it to the Gold Lake Company, by whom it was worked for a time in a very quiet manner. Specimens rich in gold, and comparing favorably with those from the Michigan, were secured. This vein is also in the diorite, and felsite shows in places cutting through the diorite. The vein "pinched" out at a depth of something like 60 feet, and its continuation was not sought beyond a few feet where lost sight of.

THE SUPERIOR GOLD MINING COMPANY

did some work on the northeast quarter of northwest quarter of Secs. 35, 48-28. This was immediately east of the Michigan property, and the vein was in the diorite. Some fine specimens were secured, but the work was given up soon after it was begun. The vein is said to have been cut out by the diorite.

THE PENINSULA MINING COMPANY,

made up of Detroit, Mich., capitalists, did some work under the above title on the southwest quarter of the southwest quarter of Secs. 25, 48-28. A shaft was sunk 70 feet. The quartz here is in granite and is in small stringers. Free gold was seen, and the company figured that they could treat all the granite impregnated with this quartz. Numerous assays were made and the company reported these to be satisfactory. They have not done anything in the way of equipping the property.

Other properties were worked more or less, the Grummett, Swains, Mocklers, Grayling and Giant being prominent at the time the excitement was at its height, but all work has stopped. These were all on the Michigan range.

THE DEAD RIVER DISTRICT.

One of the most promising territories for the existence of gold is known under the above title. In the sixties there was great excitement in the field due to the discoveries of silver secured from the Holyoke mine, but the lead did not prove rich enough in the more precious metal, and all work was finally abandoned.

This district begins in the Dead River valley starting about eight miles north of Ishpeming and extending northward to Lake Superior. The particular portion of this field as thus far exploited can be located by a line drawn centrally through it from east to west, which line would agree with the line of town 49. The eastern terminus can be placed at Lake Superior. Westward it extends several miles. The honor for first bringing this district to the attention of the people of the State was accorded Julius Ropes, who made his initial discovery here in June, 1890.

In town 27 there is a spur that leaves the main range, going at a sharp angle to the northwest. This is locally termed the north range, and the one from which it diverges, the south range. The south range appears to be the principal gold bearer so far as tests of the rock have been made. In width the range altogether is about three miles.

Small quartz seams are innumerable. The seams of quartz run in size from an inch to several feet, and many of them are gold-bearing. The predominating minerals are copper ore, iron pyrites, galena, and sometimes zinc. No refractory ores are discovered. Tellurium has also been found in a trachitic greenstone, and it is reported from no other portion of this region.

The configuration of the surface of this field is attractive. The granites and traps sometimes rise to a great height, forming deep defiles, reminding one of the canyons of the west. The schists and softer rocks have been gouged out, making the surface very rugged, full of gulleys and corresponding hills. It certainly is an attractive region, and one that has not commanded the attention from gold hunters which it deserves.

Following the discovery of Mr. Ropes in this field, a company was organized that secured options on a large tract of land, and conducted explorations on Secs. 35, 49-27 under the title of

THE FIRE CENTRE MINING COMPANY.

Two shafts were sunk upon different veins in the granite, and were carried downward about 100 feet. At this depth there was a diminuation of gold in the rock and the company ceased operations much to the disappointment of the many who were interested. As in the case of other explorations in this region, those who undertook development work were unfamiliar with gold mining. They were too easily discouraged.

In the summer of 1892 a trial lot of rock was treated in the Ropes gold mine mill. This consisted of 254 tons, and from it were produced $2,063 worth of gold, about $8.12 per ton, a most gratifying result. The gold was 69.7 fine, and the percentage of saving in the mill, including concentrates, was 76.7, showing the free-milling qualities of the rock. The latter stamped very preely, much more readily that that of the Ropes mine. The Fire Centre Company ordered a Crawford mill, which was set up and proved an utter failure. In the fall of 1898, the shafts having changed from pay quartz to barren, work was stopped, and the place has been abandoned. I consider this the most promising of the several gold fields in this region, and believe if it had skilled men to direct operations a success would be achieved. The tract is a large one, and little or nothing has been done.

I have been shown rich specimens that are said to have been taken from Baraga county, and from near Lake Michigamme. Nothing is now being done in that section.

Two miles north and east of the Ropes, Edward Robbins, of Ishpeming, found gold in the summer of 1895, and obtained many fine specimens showing the native metal.

This gold is associated with the iron ore-bearing formation.

GROSS VALUE BULLION MICHIGAN GOLD MINES.

Ropes Gold and Silver Company	$605,056 95
Michigan Gold Company	17,699 36
Fire Centre Gold Mining Company	2,063 00
Other prospects	820 00
Total	$625;639 31

PLACER GOLD.

Placer gold from the fluvio-glacial deposits of the state has been reported from a number of localities, some of which are well authenticated. The source of the gold is doubtless in the gold-quartz veins which are known to occur widely distributed in the Archean rocks of the Lake Superior region.

What gold there is in the glacial drift of the Lower Peninsula has been transported from the north in the same manner as other materials of the glacial drift and should be put in the same category as "float" copper, and "float" iron ore, as being no indication whatever of the existence in this part of the state of the original source of the metal. Very lean placers may result from concentration by stream action of the gold particles in the glacial drift but we have no proof that any of the deposits reported have any value, commercially, nor is it thought that any of them either known or unknown are valuable. To produce a workable concentration from the widely scattered particles of gold which are in the glacial drift of the Southern Peninsula would require a sorting by water action of such magnitude and completeness as to be wholly beyond the probabilities.

Chances in favor of the occurrence of valuable gold placers in stream gravels of the pre-Cambrian area of the western half of the Upper Peninsula are decidedly greater than elsewhere in the Paleozoic areas of the state for the reason that in the pre-Cambrian rocks are the only known or even probable original sources of gold in this state and the drift in some parts of this area is mainly of local origin. Yet even in these areas the possibilities of the occurrence of placer "pay dirt" are sufficiently meagre to discourage prospecting with any hope of commercial reward.

In the Annual Report for 1906, Dr. A. C. Lane quotes a letter from W. M. Courtis of Detroit giving localities from which placer gold has been reported. Some of these occurrences have been authenticated.

Mr. Courtis says: "At Lowell and along the Grand River there is gold in a certain channel that crosses the river near this place. This gravel is composed of a different kind of pebbles from the gravel found in the high banks along the river which rise in some places two or three hundred feet above. The gold in the Grand River begins at Maple River and was found down to Ada Creek and probably down to the lake, no gold being found in the most favorable bars above the former place.

These high bluffs are stratified in some places, at others irregular deposits. None of these strata would pan gold even taking the ferruginous seams, the most promising, except in the lower seams a few colors were found.

The gravel in the old river channel seems sufficiently rich to work with dredges in some parts where the land is not too valuable and as this old channel apparently comes from the northwest. There seemed to be a steady increase in the colors of gold as depth is gained—pans running from four to thirty colors. The total average of all our tests was about three cents per cubic yard, though very little digging was done, only taking up the mussels and panning the gravel. The estimate of three cents included all the barren dirt that was tested, barren gravel that overlays the old bed and is not any criterion of what the river channel would run, which should be tested with six holes. The gold was much coarser than I would suspect, some of it being like mustard seed.

I thought it had been "salted" but I walked out a rod or two from the shore, dug up the mussels and alone washed the dirt. Here I got but one to four colors to the pan. This gravel contains a large amount of black, magnetic sand, iron, garnets, zircons and is analogous to those deposits worked in Russia which in their richest parts yield from two to four dollars per cubic yard.

The following is a list of the places where gold is said to have been found in the gravel:

Washed by myself.

Maple River, Ionia County.
Lowell, Kent County.
Ada Creek, Kent County.
Grand River, below Lyons, Ionia County.
Flat River, Ontonagon County.

Iron River.
Ishpeming, Marquette County.

Reported discoveries.

Birmingham, Oakland County.
Union City Branch, to the S. E. and S. W. (?).
Marcellus, St. Joseph County.
Burr Oak, St. Joseph County (pyrites likely).
Grand Haven, Ottawa County.
Allegan, Allegan County.
Greenville, Montcalm County.
Howard City, Montcalm County.
County Line, Newaygo County.
Muskegon River, Newaygo County.
Whitehall, Oceana County.
White River, Oceana County.
Elbridge, Hart, June 7, 1906.
Little Sable River, Manistee County.
West Summit, Wexford County.
Manistee River, Manistee and Wexford Counties.
Walton, Kalkaska County.
Rapid River, Kalkaska, Kalkaska County.
Leelanau County, near Lake.
Antrim County, same river (nuggets, reliable).
Boyne River, Charlevoix County.
Little Traverse, Emmet County.
Victoria Copper Mine (large nugget).
Ishpeming district, near gold mines.
At points south of Gogebic Iron Range.

The following places were reported but believed to be only pyrites:

Cheboygan, Cheboygan County.[1]
Alpena, Presque Isle County.[1]
Caseville, Genesee County.[1]
Flushing, Genesee County.[1]
Caro, Tuscola County.[1]
Near Fargo, St. Clair County.
T. 8 N., R. 14 E., ($6.00 a ton?)
N. E. 1/2 S. E. 1/4 Sec. 33, T. 49 N., R. 42 W., Tr. Au. 15c Ag.

[1] Iron pyrites, examined.

In addition to the above localities Dr. Lane reports the finding of a nugget on bed-rock at Williamston, Ingham County, by Mr. Taylor, and a statement that Mr. Jos. B. Seager has washed as many as 20 colors to a pan in the Huron Mts. where the drift is of local origin.

OIL AND GAS IN MICHIGAN.[1]

BY R. A. SMITH.

CONTENTS.

EXPLORATION FOR OIL AND GAS.

Much exploration for oil and gas has been done in many parts of Michigan, but the results have been, on the whole, meagre in extreme. Only at Port Huron and near Allegan has oil been discovered in quantities approaching commercial importance. A recent report, however, indicates a possible occurrence of oil in quantity at Osseo, in Hillsdale county. The scant success may not be entirely due to a general absence in Michigan of these mineral products in commercial quantities, but very possibly, it may be largely due to the manner in which such exploration has been carried on.

As a rule the drillings have been very scattered, haphazard, and relatively shallow when compared with the depth of the oil horizons as they exist in this state. A single drill hole, though deep, can hardly be considered a positive test, determining the presence or absence of oil or gas in any particular area, since a large majority of the drillings even in a proven territory are "dry holes." Most of the companies organized for oil exploration sell their stock at so low a figure that, after paying the necessary expenses of organizing, salaries, etc., there is little left for adequate development work. Drillers as a rule have known little or nothing of the

[1]Compiled largely from the writings of Dr. A. C. Lane, as found in Volume V, Part 2, 1895, and the annual reports of the Michigan Geological Survey for 1901, 1903, 1904 and 1908.

major structure of the Michigan basin, the formations, or the relative depths of the same. Often it has happened that the driller has gained his knowledge of oil conditions and occurrences from experience in other fields, as Ohio, etc., and begins operations with a false notion that similar conditions obtain in Michigan. Consequently, after drilling a few hundred feet without finding either the Trenton or Berea, the coveted goals of the Ohio drillers, he becomes discouraged and gives up the attempt. The money spent is wasted, as nothing definite either one way or the other, regarding existence of oil or gas, has been determined.

Anyone, contemplating development work for oil and gas in Michigan, should have a general knowledge of the usual conditions under which these mineral products occur and, as far as possible, a specific knowledge of the major geological structure of the Michigan basin, the nature, thickness, and depth of the formations, the possible oil horizons, and the location of minor structures, such as folds or anticlinals, which may be superimposed upon the major structure. The general and the specific facts most pertinent to any oil or gas exploration work in Michigan might be summarized as follows:

1. A general geological structure most favorable for the accumulation of large bodies of oil and gas is a broad *upward* fold, or anticline, with numerous minor folds, or anticlines, superimposed upon the major structure. The oil and gas being lighter than the waetr, make their way upward through porous layers and collect at the crests of the minor folds underneath impervious layers such as shales, etc., forming accumulations known as "pools." Obviously "dry" holes will be the general rule except near the crests of the anticlinals.

2. The above general conditions are idealized in the Nashville and Cincinnati anticline, the broad dome or rather arch running from Tennessee northward through Ohio into western Ontario. It is chiefly on the crests of the numerous minor folds of this great anticline that the oil pools of Ohio occur.

3. The major structure of the sedimentary rocks of Michigan is a broad *downward* fold in which the formations lie one upon another like a pile of gigantic shallow saucers, each successively higher saucer being smaller than the one next below.

4. The major structure is thus *diametically opposite* to that obtaining in Ohio and Tennessee and the minor flexures or anticlines are apparently not only much fewer but much less pronounced in Michigan. The general conditions are such that they

are more favorable for the escape of the oil and gas rather than for their accumulation.

5. Apparently, the main hope of finding oil and gas in commercial quantities in Michigan lies in the occurrence of the above mentioned minor folds or anticlinals, or of *other* structures serving the same purpose.

6. Eight possible or probable anticlinals (Fig. 19) have been approximately located and the chances for finding oil and gas are presumably much greater in their vicinity than elsewhere.

7. The formations as a whole becomes deeper toward the center of the basin, thus the Berea Grit coming to the rock surface beneath the drift near Harrisville, Alcona county, is found at more than 2,000 feet below the surface in the Saginaw valley. The Trenton outcropping in the channel of St. Mary's river and at Limestone Mountain in the southern part of the Keweenaw peninsula, is probably 5,000 feet or more beneath the surface in the central part of the Lower Peninsula.

8. A knowledge of the approximate depth at which any given horizon may be reached and the number of water-bearing horizons to be encountered is essential both from a practical and financial standpoint. Sometimes the drilling is a failure because the hole is too small to allow for casing off water the necessary number of times before the oil horizon is reached, or because the desired horizon is so deep that the capital is exhausted before the completion of a single hole, to say nothing of a number sufficient for an adequate testing of any given territory.

OIL FIELDS AND DISTRICTS.

Port Huron Field. Oil and gas in small quantities has been found almost everywhere in the state, but only at Port Huron has the quantity been deemed sufficient for exploitation on a commercial basis. The development of the Port Huron district, which extends for several miles along the St. Clair river above and below the city, has been due largely to the energy and enterprise of the late Mr. G. B. Stock of Port Huron. The Michigan Development Company, organized by him, has drilled many wells in the vicinity of Port Huron, and has, in the western part of the city, a group of 21 wells which yield altogether some 70 barrels of heavy oil per week. This production, though insignificant when compared with those of Ohio and other fields, is more than sufficient, under favorable conditions, to pay operating expenses, but, of course, the net returns are disproportionately small in comparison with the original outlay made in putting down the wells.

The oil is very heavy and a natural lubricant and is used as a base in the manufacture of the superior lubricants made by the G. B. Stock Xylite Grease and Oil Company of Port Huron.

Almost all of the test holes in the Port Huron district give a show of gas and oil. Some wells, at first, yield two to three barrels per day, but, after a few weeks, the yield gradually decreases until an average yield of about a half a barrel a day is reached. According to report, several of the wells have been producing for about 15 years and show no positive signs of exhaustion. It is this constancy of production that forms the ground for a firm belief upon the part of the oil promoters at Port Huron that a pool of oil must exist somewhere in that district.

Gas is present in most of the wells and it is in sufficient quantity in the Michigan Development Company's wells that it is used as the motive power for a 25 H. P. gas engine which drives their pumping machinery. Many farmers, especially south and west of Port Huron, in Macomb, Oakland, and other counties, strike gas under impervious beds of clay in wells, in quantities sufficient for household purposes. In fact, there are several other places in the Lower Peninsula, especially in the southeastern and northern parts, in the Manistee district, and in Monroe county, where gas has been found either in drift or rock wells in quantities that warrant utilization for such purposes.

The oil horizon at Port Huron is the Dundee, which at Petrolia and Port Huron is a constant though often modest producer of oil and gas. The depths of most of the oil wells range from about 500 to 650 feet, though there are a few shallower or even deeper. Mr. Stock for many years entertained the idea of financing a project for sinking a well down to the Trenton, but his sudden death in 1910 put an end to further efforts in that direction. From the records of the salt wells at Port Huron, the first salt in the Salina appears to occur at about 1,500 feet. Judging from this, it would require a well probably more than 3,200 feet to reach the Trenton.

The numerous drillings at Port Huron and four or five miles north of the city along Black river, indicate the presence of a low anticlinal in the Dundee, running through the southern and western portions of the city and then veering to the northward along Black River. Some exploration on the northern extent of this anticlinal in 1910 and 1911 near Black river has resulted in the reported discovery of oil and gas in small quantities comparable to the flows found in the Port Huron wells. Possibly the oil is so distributed through the oil formation that only small flows of oil and gas will ever be found in the Port Huron district.

Southeastern District. The southeastern district, extending from Macomb county southwestward through Wayne and Monroe counties to Ohio, should really include the Port Huron district, which has been deemed worthy of separate discussion. In this district, oil in small and gas in considerable quantities have been encountered in numerous wells. Especially is this true in belts underlain by the Antrim, Traverse, and Dundee formations. As noted in the discussion of the Port Huron district, drift gas wells are numerous in St. Clair and Macomb counties. The same conditions obtain, though perhaps to a lesser degree, from Monroe county to the Ohio line.[2]

In the northeastern part of Monroe and in parts of Wayne county, oil impregnates the rocks, forms a scum over ponds and streams, in wells and around springs, and gives off an offensive odor to the water. Gas in bubbles or sometimes in continuous streams rises up through the water in many instances in quantities sufficient to be ignited. This is the so-called surface or shale gas, which usually has a relatively small volume, and no great pressure, but still it is often sufficient for utilization for household purposes. The gas is used mainly for heating as it is deficient in illuminants, and gives very little light. Though a well may last only a few years, another can be put down at small cost.

Monroe county, lying close to the Toledo oil fields, naturally has been well prospected, though with practically barren results. Small quantities of oil and gas, however, were found in all of the drillings. Ten or more deep wells, six to the Trenton, have been put down in the county, mainly in the southeastern part. The wells at Monroe, at Dundee, etc., showed that unfortunately Monroe county was too far down the western slope of the Cincinnati anticline, which extends from western Ohio into Ontario, to contain oil and gas in any great quantities. In the F. C. Potter well (N. W. ¼ of the N. W. ¼ of Section 22, Erie township), which was the nearest to the Toledo fields, the Trenton was struck at 1,555 feet and penetrated 112 feet. The gas, with an original pressure of 25 pounds, has been utilized for household purposes. The well also contains some oil and has been "bailed" out several times, yielding as much as 10 barrels in one case. None of the other wells were as productive and, significantly, the wells farthest

[2]Sherzer's report on Monroe county, Vol. VII, Part 1.

away from the Ohio fields were, in general, the more unproductive.

Well records of Monroe county and at Milan, Ypsilanti, Ann Arbor, etc., seem to indicate a uniform dip of 29 to 32 feet of the formations from Monroe county toward the northwest to Ann Arbor and beyond, with no indication whatever of a minor fold.

In Wayne county, however, near Wyandotte, there appears to be a low anticlinal (See Lane, Annual Report, 1901) coming across the Detroit river and dipping sharply to the northwestward. The strata in the Sibley quarries dip to the southwest instead of the northwest, the direction of the normal dip, and the Sylvania sandstone (See reference table of horizons) in the Solvay well No. 6 (Lane, Annual Report, 1901) at Detroit and in the Canadian Pacific R. R. well No. 11, Windsor, is some 30 feet or more deeper than in the Tecumseh Salt Company wells near River Rouge. The Ford (Michigan Alkali Co.) wells at Wyandotte, however have shown no noteworthy amounts of gas or oil.

North of Mt. Clemens the normal northwesterly dip of the formations suddenly becomes northerly, as shown by the records of the wells at New Baltimore, Mt. Clemens, etc. The change in dip is indicative of the presence of an anticlinal which probably runs from somewhere near Mt. Clemens toward the central basin.

Southwestern Part of the State. A number of deep wells have been sunk for oil or water at various places in the southwestern part of the state, as at Kalamazoo, Dowagiac, Berrien Springs, Bridgman, Benton Harbor, Niles, White Pigeon, Constantine, Allegan, etc., but, though oil and gas were encountered in many of the wells at one or more horizons, only at Allegan was oil reported in possibly commercial quantities. Several wells from 1,300 to 1,400 feet or more in depth, were bored, oil being found in every case. The No. 1 well of the Allegan Oil and Gas Co., according to Mr. J. C. Ellinger, president of the company, gave a yield of about 5 barrels of oil per day, which was not materially increased by shooting. For about 6 weeks or more their No. 1 well averaged a little more than 3 barrels per day of 24 hours and nearly enough gas to heat the boiler. These wells were abandoned at the end of the tests as not being worthy of further attempt at exploitation. If a group of such wells could be put down close enough together to be pumped from a central plant, as at Port Huron, their aggregate yield might possibly be sufficient to make a fair return upon the original investment in putting down the wells. It must be said, however, that the oil horizon at Allegan, which is apparently in the Dundee at approximately 1,250 feet, is about twice as deep as at Port Huron, therefore the cost of sinking the wells would be much more. The numerous drillings in southwestern Michigan and in northern Indiana, indicate a prominent trough or synclinal, pitching slightly north of east from Bridgman in Berrien county and running through Berrien Springs and Dowagiac, and an anticlinal (Lane, Annual Report, 1903, p. 285) which comes in near Elkhart, Indiana (Fig. 19) passing a few miles east of Niles in a northeasterly direction. Obviously, the region of the Berrien Springs "trough" may be classed as unfavorable territory for oil exploration, while the territory a few miles east of Niles might be worthy of exploration not only to the Traverse and Dundee, but down to the Trenton, which, very doubtfully indeed, has been penetrated, anywhere in the southwestern part of the state, contrary to the many reports. It is in this part of the state that drillers have frequently mistaken the black Antrim shales just above the Traverse for the black shales above the Trenton, and have abandoned the field with a false notion that they had proven the Trenton to be a barren horizon.

Western Michigan. In the vicinity of Muskegon, a considerable number of deep wells, since the early 70's have been drilled at various times for a variety of purposes, most of which, however, were for salt. The Whitney and Truesdale, also called the Hacker (1,230-1,600? ft.) the Mason (2627 ft.) and the Ryerson hills (2,050-2,200 ft.) are some of the older and notably deep ones. In the latter two, some oil was found at about 1,200 ft., which, judging from the quality of the oil, seems to be the horizon of the Berea. The Ryerson, some years ago, according to reports, continually exuded oil to the amount, probably exaggerated, of half a barrel per day.

In 1900, two 1,500-foot wells, one near the Ryerson and the other, the Michigan Oil Company well, only about 40 feet from the Mason, were sunk for oil, which was encountered in small quantities at 1,227 feet and 1,275 feet respectively. The Central Paper Company in 1903 put down a 1,650-foot well (Muskegon No. 6, Lot 1, N. E. 1/4, Sec. 34, T. 10 N., R. 17 W., about 4 1/4 miles westerly from the Ryerson) 35 feet, into the Traverse, finding little or no oil or gas.

The Ryerson, Central Paper Company, and Mason wells, though not exactly in line are near enough for a practical comparison of the relative positions of the corresponding strata as they occur in the respective wells. The easterly dip across the lake from Milwaukee to the center of the Michigan basin (See Annual Report, 1901) appears to be about 20 feet per mile, and the strata should be deeper in the Ryerson well than in the Michigan Oil Company and Mason wells to the west, but this is not the case, as a red fossiliferous limestone, which comes in from 890 to 914 feet, and other corresponding strata in the Michigan Oil Company well appear at higher horizons in the Ryerson. Lane (Annual Report, 1903) thinks that if further attempts are made for oil, it would be well to drill further up the shore of Lake Muskegon in the region of Section 16 and 17, T. 10 N., R. 16 W., in the hope that the crest of the anticlinal might be in that direction. The fine grained character of the oil sand, however, would probably prevent a free flow of oil, unless an exceptionally coarse phase of the formation should be struck. Oil or gas might possibly be found at the same place by going down to the Dundee, which ought to be reached at about 2,100 feet.

In the Manistee district, the deep wells, some 30 or more, are scattered from the Canfield-Wheeler (Sec. 11, T. 20 N., R. 17 W.) well, near Lake Michigan, to Stronach and Filer City, a distance of 5 or 6 miles. The Canfield-Wheeler well, originally 1,947 feet in depth, was afterwards deepened some 500 feet to the white Guelph or Niagara dolomites. In most of the wells, oil and gas were found in very small quantities but in the R. G. Peters (Sec. 7, T. 21 N., R. 16 W.) quite a little oil and gas occurred at 1,905 feet. In fact, water and oil was blown 150 feet above the derrick, the top of which was blown off. Some gas was also noted at about 600 feet in some of the wells.

In the Buckley and Douglass No. 5 well and the R. G. Peters wells, the salt horizons occurred at practically the same depth, 2,015 and 2,026 feet respectively. To the southeast toward the head of the lake at Stronach, the salt is encountered from 1,930 to 1,964 feet. The base of the Traverse is also higher (See table of horizons) with signs of oil and gas just below. The normal eastward dip of the formations across Lake Michigan is apparently from 40 to 50 feet per mile and, according to this, corresponding horizons at Stronach and Filer City should be from 200 to 300 feet deeper than in the wells to the northwest in Manistee, but, in reality, the horizons are as high or higher in former wells than in the latter. From this, an anticlinal in the formations down to the salt beds must exist near Stronach, and might contain oil and gas in quantity. Since to the southeast of Stronach for several miles, there are no drillings deep enough to reach bed rock through the thick surface deposits, the position and direction of the crest of the anticline can not be determined. Its crest apparently may run through Stronach or Filer City or it may lie considerably further east.

Central Part of the State. Hundreds of drillings have been made for coal, salt, or oil in Saginaw valley. The earlier deep drillings were mainly for salt, and little attention was given to the nature of the formations lying above the salt horizons or their possible economic products. From drillings in various places in Saginaw valley and around Saginaw Bay as at Bay City, Saginaw, Midland, and at Kawkawlin, Bay county, at Blackmar, Saginaw county, Caseville in Huron county, Tawas City, Iosco county, etc., the general average southwesterly dip from Bay City toward the center of the basin appears to be approximately 20 feet per mile. Drillings for salt or oil have shown, however, that the formations at least down to the Marshall brines, rise and occur at even considerably higher levels at Saginaw than at Bay City instead of being several hundred feet deeper as they should, according to the general average dip to the southwest.

At Bay City, the brines at Hargraves Mill on Middle Ground in the southern part of Bay City are struck at the depth of 1,040 feet, but to the north at Pitts and Cranages, near the Michigan Central railroad bridge, at the Detroit and Mackinaw bridge, at Boyces in Essexville, and at Kawkawlin, which is a little north of west from the city, the brine horizons occur from 40 to 300 feet higher. Going south from Middle Ground in Bay City toward Saginaw, the brine horizons of the Marshall rise. In the South Bay City well (North American Chemical Co.) the brines come in at 850 and 890 feet, in the Melbourne wells half way to Saginaw at 890 feet, in the old New York and Saginaw Salt and Lumber Co. wells two miles north of Zilwaukee at 760 and 867 feet, in the Bliss well at Zilwaukee at 665 feet, and in the old East Saginaw Salt Co. wells from 633 to 742 feet. At the Wylie well in central Saginaw, it is said to be but 715 feet to the bottom of the brine horizons, the brine being struck probably at about 620 feet. Southward and westward from the Wylie well the horizons deepen rapidly, occurring in the Saginaw Plate Glass Company wells from 820 to 900 feet, at Garfield over 800 feet and at St. Charles 800 to 900 feet. Westward from Bay City at Kawkawlin the brine horizons are higher than in Bay City, being encountered at depths from 700 to 800 feet.

In the Monitor Oil and Gas well and in the Ralston well (Sec. 4, T. 13 N., R. 4 E.), near Bay No. 2 mine, it appears that there is a strong upward fold of the coal measures and that the indications point to the extension of this fold down into the underlying horizons. From the records of the Midland, Alma, St. Louis, and Mt. Pleasant wells, the Marshall occurs from 1,000 to 1,400 feet and thus indicates a decided dip westward from Kawkawlin.

From the foregoing facts, it appears that a pronounced anticlinal in the formations down to the Marshall must exist between Midland and Bay City. The data indicate that its crest probably passes through Saginaw near the Wylie well and run a little west of north, passing near the old Monitor mine, and through a point 3 or 4 miles west of Kawkawlin. It is no known, however, whether the formations below conform to this upward arching of the Marshall, although there are some indications which point to such a conclusion.

The many drillings down to the Marshall have shown that the possibilities for the occurrence of oil and gas in quantity in the Pottsville or Marshall formations in the region of Saginaw and Bay City are decidedly limited. The Berea is the next lower horizon with possibilities for carrying oil and gas in quantity. This formation, a coarse gray sandstone full of pure strong brine, was encountered in the South Bay City well at about 2,100 feet. Strong signs of oil and gas were observed at 2,080 feet in the Berea shale above. As none of the Saginaw wells, however, reach this horizon, it is very uncertain whether or not the Berea conforms to the minor folds of the overlying Marshall and Coldwater. Since the Berea is very variable in character, it may not be porous enough to contain gas in quantity or it may be too fine grained to yield a ready flow of oil. A redeeming feature that lends itself to prospective explorations down to the Berea is that the drilling from the Napoleon or Upper Marshall down, is very easy, requiring only 3 weeks in the case of the South Bay City well to go through the 1,100 feet or more shales and sandstones. If no oil was found in the Berea the brine might be of value, especially if it should contain a high percent of bromine, etc.

Elsewhere in the central basin of the state outside of the Saginaw valley drillings for oil have been made with the most barren of results, excepting possibly at Fowlerville. The record of a well near Morrice, Shiawassee county, seems to indicate the presence of an anticlinal down to the Berea. In the wells at Blackmar, Saginaw county (See table of horizons), Columbiaville, Lapeer county, and Flint, on the eastern side of the basin, Jackson, Assyria, and Charlotte in the southwestern, the Berea or its horizou and the Marshall are apparently deeper than at points between. This anticlinal apparently runs from near Fowlerville in a northwest and southeast direction passing somewhere near Laingsburg, Shiawassee county, and may be a continuation of the one at Wyandotte, Wayne county. Northwest of Fowlerville, Livingston county, on the Grill farm on Sec. 17, T. 4 N., R. 3 E., a well was sunk to a depth of about 1,000 feet, oil and gas being found in small quantities at 120, 155, 380, and 600 feet. In the Fowlerville oil well, 2 miles south of Fowlerville (N. E. 1/4 of Sec. 6, T. 3 N., R. 4 E.) oil and gas were struck at the shallow depth of 136 feet in a blue shale underlying sand rock. The flow of oil was very small, being possibly a half barrel a day. Another well, reported to be 2,300 feet deep, was put down on the Z. Lazell farm, some 6 miles west of Lansing, apparently without finding any marked signs of oil or gas whatever. On the whole, the central part of the state with its deeper lying horizons and almost wholly unknown minor structures, if such exist, does not appear to offer the same chances of success, meagre as they may be, as the regions nearer the margin of the state.

Northern Part of the Lower Peninsula. The black Devonian shales underlie the surface deposits in a broad belt extending across the northern part of the state from Manistee county through Antrim and Charlevoix to Alpena county. Almost anywhere in this belt abundant signs of oil and gas are found. The same is true where the more limited Berea outcrops beneath the drift, as in Alcona county. Numerous springs, as at Killmaster, and along Black river, etc., boil just from the abundance of gas given off, which is sufficient, it is said, to give a flame several feet high when lighted. Considerable bodies of gas are often encountered in the drift, as at Killmaster, and, since the drift is in most of the interior counties several hundred feet deep, it is quite possible that accumulations of gas underneath impervious beds of clay may be found of sufficient size and pressure to warrant utilization on a commercial scale wherever the Berea, as in the region of Harrisville, Atlantic, and Vanderbilt, or the Devonian formations form the underlying bedrock. But it must be said in this connection, that surface signs and occurrences of oil and gas are not necessarily favorable signs of more oil and gas below. Such signs and occurrences indicate, if anything at all, a leaky and therefore probably empty reservoir in the oil formation beneath.

In the deep Killmaster wells, oil and gas were found in small quantities in the Berea, but these wells together with the three

Oscoda wells seem to indicate that the Traverse is not only dry but without oil or gas. The drift in the interior counties is generally so deep that ordinary wells do not reach bed rock and the deeper drillings are so widely scattered that there is no positive evidence of an existence of an anticlinal in the oil and gas bearing formations. All of the formations, judging from the borings at Cheboygan, Killmaster, Alpena, Oscoda, Grayling and Alma indicate an undisturbed dip of 30 to 40 feet per mile to the south or toward the center of the central basin. On Little Traverse Bay, however, near Khagashewung Point (Fig. 19) the Traverse formation shows in its outcrop some minor folds which pitch gently toward the south. It is barely possible that the underlying Dundee might carry oil and gas in quantity in the region of these minor flexures.

Upper Peninsula. Wherever drillings in the Upper Peninsula have reached the Trenton, oil or signs of oil and gas have nearly always been encountered. In its outcrops, and also when struck in borings, the dried oil residue, or asphaltic gum is often found filling cavities and fissures in the limestone. Near Rapid River, between Whitefish and Rapid river there was such an abundance of this asphaltic material in the rocks that a serious attempt was made to discover a commercial deposit. In the Rapid River well oil was apparently struck in quantity at a depth of about 1,000 feet, but afterwards, it was found that the well was yielding comparatively little oil and much water. The oil seems to have come from vugs in the limestone at a much higher horizon than 1,000 feet, as such depth would be very probably down in the pre-Cambrian. The same might be said for the occurrence of the oil in the Marinette well just across the line in Wisconsin.

Wells on Neebish, Manitoulin, and Drummond islands, at Escanaba and St. Ignace showed little or no oil or gas and also indicate that the formations dip much more steeply toward the central basin than the formations in Lower Michigan. The dip of the Trenton from Neebish to Cheboygan appears to be over 60 feet to the mile and nowhere does there seem to be any marked evidence of a disturbance of the general average dip for a given region. Of course, the drillings in the Upper Peninsula are so scattered that minor flexures would hardly be discovered, should they exist.

Fig. 19. Map showing the position, course, and pitch of the anticlinals which appear to exist in the underlying formations in Michigan.

2 ~~1~~. Anticlinal running through the southern part of the city of Port Huron and then veering to the north along Black river.

3 ~~2~~. Anticlinal of indefinite position near Mt. Clemens.

4 ~~3~~. Anticlinal coming across Detroit river at Wyandotte and pitching sharply to the northwest.

5 ~~4~~. Anticlinal in Livingston county, which may be a continuation of the Wyandotte.

6 ~~5~~. Anticlinal coming up from Indiana near Elkhart and running northeast a few miles to the east of Niles.

1 ~~6~~. Anticlinal crossing Saginaw river near the Wylie well in Saginaw and running slightly west of north and passing through a point 3 or 4 miles west of Kawkawlin.

7. Anticlinal of unknown direction and position in the region of Stronach, Manistee county.

8. Anticlinal near Kagashewung Point, Little Traverse Bay. Pitch is toward central basin.

0. Circle indicates occurrence of oil in commercial or possibly commercial quantities.

REFERENCE TABLE OF DEEP BORINGS IN MICHIGAN BY DISTRICTS, SHOWING DEPTH, THICKNESS, AND PROVISIONAL CORRELATIONS OF THE VARIOUS FORMATIONS.

Southeastern District and Port Huron Field.	Glacial Drift—Sand, gravel and clay. Water.	Saginaw Coal Measures.—Sandstones, shales, coal seams. Water.	Parma Sandstone—White sandstone. "First brine."	Upper Grand Rapids—Limestones, sandstones, etc.	Lower Grand Rapids or Michigan Series—Limestones, shales, gypsum, sandstones.	Upper Marshall or Napoleon Sandstone—Coarse micaceous sandstone. "Second brine."	Lower Marshall—Sandstones and shales alternating. Shalier toward base and toward center of basin.	Coldwater Shales—Thick massive shales, calcareous toward western part of state. Dry.	Berea or Sunbury black shale.
Monroe, Monroe Co., A. T. 579, H. D. 1,765 Moore Well.	40								
Blissfield, Lenawee Co., A. T. ...., D. 2,402 Sec. 30, T. 7, S. R. 5 E.	120								
Adrian, Lenawee Co., A. T. 810, H. D. 1,650 Adrian Gas Co.	180							514	554
Dundee, Monroe Co., A. T. 670 ft. ±, D. 1,473	35 ±								
Manchester, Washtenaw Co., A. T. 830 ±, D. 690 Manchester Oil Co. 6 miles southeast of town.	174							327	
Britton, Lenawee Co., A. T. 700 ±, D. 1,603 +	93								
Wyandotte, Wayne Co., A. T. 580, D. 2,502	75								
Milan, Washtenaw Co., A. T. 685, D. 1,643	130								
Ypsilanti, Washtenaw Co., A. T. 682, D. 1,210 Banner Oil & Gas Co.	90							?	?
Ann Arbor, Washtenaw Co., A. T. 875, D. 1,326	235							355	415
Romulus, Wayne Co., A. T. 620, D. 1,820 E. Twark well, 6 miles northeast of Ecorse.	141								
Detroit, Wayne Co., A. T. 587 +, D. 2,097 Stroh's Brewery.	154								
Ecorse, Wayne Co., A. T. 587 ±, D. 1,323 Morton Salt Co.	62								

Algonac, St. Clair Co., A. T. 590, D. 1,727 A. Miller, 5 miles below town.	208								
Marine City, St. Clair Co., A. T. 600, D. 1,630 National Salt Co.	200								
Marine City, St. Clair Co., A. T. 600 ±, D. 1,641 Lester & Roberts.	230								
Mt. Clemens, Macomb Co., A. T. 617, D. 1,060	123								
Romeo, Macomb Co., A. T. 755? D. 1,575 Village well.	150						240 ?	1,050 ?	1,050 ?
Pontiac, Oakland Co., A. T. 934, D. 1,505 Pontiac Natural Gas and Oil Co.	320							500	535
Royal Oak, Oakland Co., A. T. ?, D. 2,502 Royal Oak Manufacturing & Gas Co.	164								
New Baltimore, St. Clair Co., A. T. ?, D. 1,640	120								
St. Clair, St. Clair Co., A. T. 600 ±, D. 1,807 Diamond Crystal Salt Co.	172								
St. Clair, St. Clair Co., A. T. 600?, D. 1,682? St. Clair Salt Works.	105								
Marysville, St. Clair Co., A. T. 600, D. 1,150 Binic Farm.	110								
[1] Port Huron, St. Clair Co., A. T. 605, D. 668 Bailey No. 1.	100								
[2] Port Huron, St. Clair Co., A. T. 605 +, D. 680 + Sec. 9, T. 6 N., R. 17 E. G. B. Stock wells.	100								
[3] Port Huron, St. Clair Co., A. T. 623, D. 772 Grand Trunk Jc. well.	124								
Port Huron, St. Clair Co., A. T. 633-589, D. 1,685 + F. L. Wells "Bore Hole."	102								
Imlay City, Lapeer Co., A. T. 830, D. 1,026 Walker & Co.	91							1,020	1,020 ?
Port Huron, St. Clair Co., A. T. 655, D. 833 Beard well, 10 miles northwest Port Huron.	138								
Valley Center, Sanilac Co., A. T. 805, D. 876	149							539	539
Petrolia, Ontario, A. T. 667, D. 1,505 "Test Well."	104								
Wallaceburg, Ontario, D. 2,100 Ten miles southeast Pt. Lambton.	120								
Southwestern District.									
[4] Bridgman, Berrien Co., A. T. 636, D. 768 Bridgman Oil and Gas Co.	258							308	
Niles, Berrien Co., A. T. 681, D. 1,099 (1,140?)	139								

[1] Show of oil and gas in nearly all Port Huron wells.
[2] Oil and gas in commercial quantities.
[3] Oil and gas at 630 ft., show of oil at 710 ft.
[4] Oil from 985 ft. to 1,020 ft.

REFERENCE TABLE OF DEEP BORINGS IN MICHIGAN BY DISTRICTS, SHOWING DEPTH, THICKNESS, AND PROVISIONAL CORRELATIONS OF THE VARIOUS FORMATIONS.

Southwestern District.	Glacial Drift—Sand, gravel and clay. Water.	Saginaw Coal Measures.—Sandstones, shales, coal seams. Water.	Parma Sandstone—White sandstone. "First brine."	Upper Grand Rapids—Limestones, sandstones, etc.	Lower Grand Rapids or Michigan Series—Limestones, shales, gypsum, sandstones.	Upper Marshall or Napoleon Sandstone—Coarse micaceous sandstone. "Second brine."	Lower Marshall—Sandstones and shales alternating. Shalier toward base and toward center of basin.	Coldwater Shales—Thick massive shales, calcareous toward western part of state. Dry.	Berea or Sunbury black shale.
Niles, Berrien Co., A. T. 681 +, D. 592. Niles Oil and Gas Co.	265	......	......	......	......	......	......	......	......
Berrien Springs, Berrien Co., A. T. 650 ±, D. 700	110	......	......	......	......	......	......	......	......
Dowagiac, Cass Co., A. T. 760, D. 1,760. Round Oak Gas & Fuel Co.	200	......	......	......	......	......	......	282 ?	282
Benton Harbor, Berrien Co., A. T. 600, D. 1,205. Benton Harbor Natural Gas & Oil Co.	135	......	......	......	......	......	......	......	......
[5]Allegan, Allegan Co., A. T. 708, D. 1,400. Allegan Oil & Gas Co.	255	......	......	......	......	......	......	990 ?	990
Goshen, Ind., A. T. 789, D. 2,054	162	......	......	......	......	......	......	......	......
[6]South Bend, Ind., A. T. 725, D. 1,670	137	......	......	......	......	......	......	......	......
Elkhart, Ind., A. T. 755 or 741, D. 615	105	......	......	......	......	......	......	......	119 ?
White Pigeon, St. Joseph Co., A. T. ?, D. 763. White Pigeon Oil & Gas Co.	182	......	......	......	......	......	......	465	465
Constantine, St. Joseph Co., A. T. 803, D. 1,080	136	......	......	......	......	......	......	286	301
Coldwater, Branch Co., A. T. 983, D. 1,200	115	......	......	......	......	......	......	816	830
Kalamazoo, Kalamazoo Co., A. T. 777, D. 2,250. Kalamazoo Natural Gas Co.	130	......	......	......	......	......	......	920	......

[5]Oil and gas. [6]Gas at 280 ft.

Assyria, Barry Co., A. T. 917, D. 2,040+ ?	240 ?					320	500		1,400
Western Michigan.									
[7] Muskegon, Muskegon Co., A. T. 594, D. 2,627 Mason well near Occidental Hotel.	210					325	625	1,200+	
Muskegon, Muskegon Co., A. T. 588, D. 2,050-2,200 (?) Ryerson Hill well.	298							1,427	
Muskegon, Muskegon Co., A. T. 592, D. 1,500 Michigan Oil Co. 40 ft. from Mason.	235						340	1,500	
Muskegon, Muskegon Co., A. T. 592±, D. 1,650 Central Paper Co., N. E. ¼ Sec. 34, T. 10 N., R. 17 W.	233						310	1,323+	
Ludington, Mason Co., A. T. 590?, D. 2,304 Stearns Lumber and Salt Co. Well.	576								1,200
Ludington, Mason Co., A. T. 590?, D. 2,220 Pere Marquette Lumber Co.	528								1,200±
Ludington, Mason Co., A. T. 600, D. 2,260 Butters & Peters well, 1 mile south of Pere Marquette well.	545±								1,200±
Manistee, Manistee Co., A. T. 604, D. 1,947+500± Canfield-Wheeler.	715±								
[8] Manistee, Manistee Co., A. T. 590±, D. 2,026 R. G. Peters Well.	614								
Manistee, Manistee, Co., A. T., 610 D. 2,015 Buckley & Douglass Lumber Co. No. 5.	616								
Stronach, Manistee Co., A. T. 604, D. 1,972 Stronach Lumber Co.	570								
Frankfort, Benzie Co., A. T. 600+, D. 1,800 A. G. Butler.	527±								
Central Michigan.									
Caseville, Huron Co., A. T. 590?, D. 3,230	100	175			422	722	982	1,878	1,980
Bay City, Bay Co., A. T. 590, D. 2,865 Atlantic Mill in North Bay City.	120	585	635 ?		830		920	1,600+	2,118
[9] South Bay City, Bay Co., A. T. 592±, D. 3,508 North American Chemical Co. "Rock Salt" Well.	105	490	540	620	840	970	1,290	2,060	2,100
Saginaw, Saginaw Co., A. T. 600, D. 900 Saginaw Plate Glass Co., Saginaw Town.	101	474	535	616	820	898	900+		
East Saginaw, Saginaw Co., A. T. 588, D. 800 East Saginaw Salt & Mfg. Co.	92	292+	398 ?		636	797	800+		
Saginaw, Saginaw Co., A. T. 585±, D. 710+ ? Wylie Well.	90±				620±	710	710+		
Midland, Midland Co., A. T. 590±, D. 1,200 ?	155					1,050+			
Mt. Pleasant, Isabella Co., A. T. 770, D. 1,555	400	810	840	1,050	1,408		1,550±		
Alma, Gratiot Co., A. T. 740±, D. 2,861	500	710	790		1,015	1,100 ?	1,500	2,250	2,300

[7] "Heavy" oil and gas at 1,200 ft.
[8] Water and oil blown 150 ft. above top of derrick, which was blown off.
[9] Signs of oil and gas at 2,070 ft.

REFERENCE TABLE OF DEEP BORINGS IN MICHIGAN BY DISTRICTS, SHOWING DEPTH, THICKNESS, AND PROVISIONAL CORRELATIONS OF THE VARIOUS FORMATIONS.

Central Michigan.	Glacial Drift—Sand, gravel and clay. Water.	Saginaw Coal Measures.—Sandstones, shales, coal seams. Water.	Parma Sandstone—White sandstone. "First brine."	Upper Grand Rapids—Limestones, sandstones, etc.	Lower Grand Rapids or Michigan Series—Limestones, shales, gypsum, sandstones.	Upper Marshall or Napoleon Sandstone—Coarse micaceous sandstone. "Second brine."	Lower Marshall—Sandstones and shales alternating. Shalier toward base and toward center of basin.	Coldwater Shales—Thick massive shales, calcareous toward western part of state. Dry.	Berea or Sunbury black shale.
Ithaca, Gratiot Co., A. T. 680±, D. 613	330	525	613	613?+					
Owosso, Shiawassee Co., A. T. 745, D. 1,100+ G. W. Collyer Well, 4 miles west of city.	126	250	473		556		601+	1,000	
Corunna, Shiawassee Co., A. T. 776, D. 907 Corunna Coal Co.	40	238	649		800		907+		
Grand Rapids, Kent Co., A. T. 605±, D. 2,220 Grand Rapids Artesian Water Co.	10				128	420	712 ?	1,500	
Charlotte, A. T. 906, D. 2,209 E. Shepherd and F. W. Higby.	72				370		680	1,660	
Jackson, A. T. 928, D. 2,455 Worthington & Cooley Mtg. Co.	22	83	300 ?				430	1,250 ?	1,400
Northern Part of Lower Peninsula.									
Cheboygan, Cheboygan Co., A. T. 590+, D. 2,725	380								
Grayling, Crawford Co., A. T. 1,140, D. 2,750 Salling, Hanson & Co.	365						540		1,540
Alpena, Alpena Co., A. T. ....., D. 1,712 Alpena Land Co. No. 1 at Grand Lake.	50								
Alpena, Alpena Co., A. T. ?, D. 1,638 U. S. Geol. Surv. Well.	375								
Grayling, Crawford Co., A. T. 1,140, D. 2,280? Grayling No. 2.	350								1,720
Harrisville, Alcona Co., A. T. 640, D. 506+?	230								260

[10] Killmaster, Alcona Co., A. T. 670, D. 1,530	240	......	......	......	......	......	......	530	570
Upper Peninsula.									
[11] Rapid River, Delta Co., A. T. 650±, D. 800+200 A. E. Neff, 7 miles northeast Rapid River.	16	......	......	......	......	......	......	......	......
Gladstone, Delta Co., A. T., 605, D. 743 St. Paul, Sault Ste. Marie R. R.	87	......	......	......	......	......	......	......	......
Escanaba, Delta Co., A. T., 600, D. Wagner Well opposite Escanaba, Sec. 8, T. 39 N., R. 21 W.	9	......	......	......	......	......	......	......	......
[11] Marinette, Wis., A. T. 600, D. 978 Marinette Water Works.	69	......	......	......	......	......	......	......	......
Neebish Island, Chippewa Co., A. T. 670±, D. 527+ American Alkali Co.	111	......	......	......	......	......	......	......	......
Pickford, Chippewa Co., A. T. 670, D. 1,425-1,500 Taylor, Holden & Van Campen.	132	......	......	......	......	......	......	......	......
St. Ignace, Mackinaw Co., A. T. 600±, D. 1,166	45	......	......	......	......	......	......	......	......

[10] Gas in top of Berea sandstone.
[11] Oil in small quantities.

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Southeastern District and Port Huron Field.	Berea grit or sandstone, white or gray, coarse and full of pure strong brine. "Third brine." Oil and gas horizon.	Antrim Black Shale—Upper part blue; sandstone lenses. Signs of oil and gas.	Traverse Formation—Top generally limestone; middle, limestone and shale; bottom, blue or black shale.	Dundee Limestone—Consistently a limestone. Oil and gas horizon.	Upper Monroe—Dolomites or "limestones." Gypsum or anhydrite, celestite and sulphur.	Middle Monroe or Sylvania—Pure white sandstone, friable and passing into sand and limestone toward the north.	Lower Monroe or Bass Island—Dolomites or "limestones," often sandy, cherty; anhydrite and celestite.	Salina—Salt, anhydrite or "gypsum," dolomites or "limestones," red, green or black shales.	Guelph and Niagara—White dolomites or "limestones," often cherty.
Monroe, Monroe Co., A. T. 579, H. D. 1,765. Moore Well.								700	1,080
Blissfield, Lenawee Co., A. T. ...., D. 2,402. Sec. 30, T. 7, S. R. 5 E.			420±						
Adrian, Lenawee Co., A. T. 810, H. D. 1,650. Adrian Gas Co.	584	800	900 ?						
Dundee, Monroe Co., A. T. 670±, D. 1,473.								1,195	1,473
Manchester, Washtenaw Co., A. T. 830±, D. 690. Manchester Oil Co. 6 miles southeast of town.	329	600	690						
Britton, Lenawee Co., A. T. 700±, D. 1,603+		210	400	500	750	1,000±	1,550 ?	1,550	1,603+
Wyandotte, Wayne Co., A. T. 580, D. 2,502				125	230	290	730	1,510	1,860
Milan, Washtenaw Co., A. T. 685, D. 1,643			298	395	535	823	1,025	1,545 ?	1,643
Ypsilanti, Washtenaw Co., A. T. 682, D. 1,210. Banner Oil & Gas Co.	?	291	520	680	1,200 ?	1,210±			
Ann Arbor, Washtenaw Co., A. T. 875, D. 1,326	520	680	930	1,040	1,240	1,326 ?			
Romulus, Wayne Co., A. T. 620, D. 1,820. E. Twark well, 6 miles northeast of Ecorse.			182	298	385	545	925	1,820	
Detroit, Wayne Co., A. T. 587+, D. 2,097. Stroh's Brewery.			300		615	700	1,150	2,097	
Ecorse, Wayne Co., A. T. 587±, D. 1,323. Morton Salt Co.					197	362	792	1,323+	

Algonac, St. Clair Co., A. T. 590, D. 1,727. A. Miller, 5 miles below town.			513	700 ±			1,500	1,727	
Marine City, St. Clair Co., A. T. 600, D. 1,630. National Salt Co.			400	625	750	1,000	1,130	1,570	1,630
Marine City, St. Clair Co., A. T. 600 ±, D. 1,641. Lester & Roberts.		360	635	770	1,060	1,130	1,485	1,641	
Mt. Clemens, Macomb Co., A. T. 617, D. 1,060	210	400 ±	610	985	1,060				
Romeo, Macomb Co., A. T. 755? D. 1,575. Village well	?			1,300	?	?			
Pontiac, Oakland Co., A. T. 934, D. 1,505. Pontiac Natural Gas and Oil Co.	808	965	1,115		1,505				
Royal Oak, Oakland Co., A. T. ?, D. 2,502. Royal Oak Manufacturing & Gas Co.		305	520	836			1,543	2,502 +	
New Baltimore, St. Clair Co., A. T. ?, D. 1,640		460	690	820			1,600	1,640 +	
St. Clair, St. Clair Co., A. T. 600 ±, D. 1,807. Diamond Crystal Salt Co.		530	790	910	1,270	1,370	1,610	1,807 +	
St. Clair, St. Clair Co., A. T. 600?, D. 1,682?. St. Clair Salt Works.		400 ±	700 ±					1,660	1,682 ?
Marysville, St. Clair Co., A. T. 600, D. 1,150. Binie Farm.		298	588	1,015	1,150				
Port Huron, St. Clair Co., A. T. 605, D. 668. Bailey No. 1.		200	543	668 +					
Port Huron, St. Clair Co., A. T. 605 +, D. 680 +. Sec. 9, T. 6 N., R. 17 E. G. B. Stock wells.		187	520	600 +					
Port Huron, St. Clair Co., A. T. 623, D. 772. Grand Trunk Jc. well.		307	625	772 +					
Port Huron, St. Clair Co., A. T. 633-589, D. 1,685 +. F. L. Wells "Bore Hole."		200	555	648	980 ?	1,215	1,555	1,740 +	
Imlay City, Lapeer Co., A. T. 830, D. 1,026. Walker & Co.									
Port Huron, St. Clair Co., A. T. 655, D. 833. Beard well, 10 miles northwest Port Huron.		238	737	833 +					
Valley Center, Sanilac Co., A. T. 805, D. 876	569	876 +							
Petrolia, Ontario, A. T. 667, D. 1,505. "Test Well."			332	600		1,100	1,505 ?	1,505	
Wallaceburg, Ontario, D. 2,100. Ten miles southeast Pt. Lambton.		449	750	1,000	?	1,100	1,700	2,035	2,100 +
Southwestern District.									
Bridgman, Berrien Co., A. T. 636, D. 768. Bridgman Oil and Gas Co.	?	508		763	768 +				
Niles, Berrien Co., A. T. 681, D. 1,099 (1,140?)		460	500	605			985		1,145 +

REFERENCE TABLE OF DEEP BORINGS IN MICHIGAN BY DISTRICTS, SHOWING DEPTH, THICKNESS, AND PROVISIONAL CORRELATIONS OF THE VARIOUS FORMATIONS.

Southwestern District.	Berea grit or sandstone, white or gray, coarse and full of pure strong brine. "Third brine." Oil and gas horizon.	Antrim Black Shale—Upper part blue; sandstone lenses. Signs of oil and gas.	Traverse Formation—Top generally limestone; middle, limestone and shale; bottom, blue or black shale.	Dundee Limestone—Consistently a limestone. Oil and gas horizon.	Upper Monroe—Dolomites or "limestones." Gypsum or anhydrite, celestite and sulphur.	Middle Monroe or Sylvania—Pure white sandstone, friable and passing into sand and limestone toward the north.	Lower Monroe or Bass ? Island—Dolomites or "limestones," often sandy, cherty; anhydrite and celestite.	Salina—Salt, anhydrite or "gypsum," dolomites or "limestones," red, green or black shales.	Guelph and Niagara—White dolomites or "limestones," often cherty.
Niles, Berrien Co., A. T. 681 +, D. 592. Niles Oil and Gas Co.		421	580	592 +					
Berrien Springs, Berrien Co., A. T. 650 ±, D. 700.		620	700						
Dowagiac, Cass Co., A. T. 760, D. 1,760. Round Oak Gas & Fuel Co.	305	765	875 ±	990 +			1,325	?	1,670
Benton Harbor, Berrien Co., A. T. 600, D. 1,205. Benton Harbor Natural Gas & Oil Co.		475	665	788 ±				?	1,205 +
Allegan, Allegan Co., A. T. 708, D. 1,400. Allegan Oil & Gas Co.		1,195	1,275	1,400 +					
Goshen, Ind., A. T. 789, D. 2,054.			470	530		?	562		1,290
South Bend, Ind., A. T. 725, D. 1,670.		350	555	800 ±		?	900		1,180
Elkhart, Ind., A. T. 755 or 741, D. 615.	?	550	615 ?	615? +					
White Pigeon, St. Joseph Co., A. T. ?, D. 763. White Pigeon Oil & Gas Co.	?	573	683	763					
Constantine, St. Joseph Co., A. T. 803, D. 1,080.	?	703	1,080 ?	1,080? +					
Coldwater, Branch Co., A. T. 983, D. 1,200.	?	1,085	1,200 +						
Kalamazoo, Kalamazoo Co., A. T. 777, D. 2,250. Kalamazoo Natural Gas Co.		1,200	1,270	1,490				1,730	2,000

Assyria, Barry Co., A. T. 917, D. 2,040+ ?		1,755	1,875	2,040+					
Western Michigan.									
Muskegon, Muskegon Co., A. T. 594, D. 2,627 Mason well near Occidental Hotel.	?	1,700		2,100			2,350	2,627	
Muskegon, Muskegon Co., A. T. 588, D. 2,050-2,200 (?) Ryerson Hill well.	?				2,050 ±		2,200?+	2,200+	
Muskegon, Muskegon Co., A. T. 592, D. 1,500 Michigan Oil Co. 40 ft. from Mason.									
Muskegon, Muskegon Co., A. T. 592 ±, D. 1,650 Central Paper Co., N. E. ¼ Sec. 34, T. 10 N., R. 17 W.	1,480	1,615	1,650+						
Ludington, Mason Co., A. T. 590?, D. 2,304 Stearns Lumber and Salt Co. Well.		1,400	2,025 ?	2,025+			2,304 ?	2,304+	
Ludington, Mason Co., A. T. 590, D. 2,220 Pere Marquette Lumber Co.		1,365	1,862	2,000			2,195	2,220+	
Ludington, Mason Co., A. T. 600, D. 2,260 Butters & Peters well, 1 mile south of Pere Marquette well.		1,490						2,260+	
Manistee, Manistee Co., A. T. 604, D. 1,947+500 ± Canfield-Wheeler.	875	1,075 ±	1,575	1,705			1,947 ?	1,947+	2,447 ±
Manistee, Manistee Co., A. T. 590 ±, D. 2,206 R. G. Peters Well.		960	1,595	1,645 ±			1,905 ±	2,026+	
Manistee, Manistee Co., A. T. 610, D. 2015 Buckley & Douglass Lumber Co. No. 5.				1,680				2,015+	
Stronach, Manistee Co., A. T. 604, D. 1,972 Stronach Lumber Co.		950	1,625				1,930	1,972+	
Frankfort, Benzie Co., A. T. 600+, D. 1,800 A. G. Butler.			1,230	1,380+	?				
Central Michigan.									
Caseville, Huron Co., A. T. 590?, D. 3,230	2,050	2,506	3,110	3,230+					
Bay City, Bay Co., A. T. 590, D. 2,865 Atlantic Mill in North Bay City.	2,306	2,585	2,822	2,865+					
South Bay City, Bay Co., A. T. 592 ±, D. 3,508 North American Lumber Co. "Rock Salt" Well.	2,270	2,580	3,270	3,508+					
Saginaw, Saginaw Co., A. T. 600, D. 900 Saginaw Plate Glass Co., Saginaw Town.									
East Saginaw, Saginaw Co., A. T. 588, D. 800 East Saginaw Salt & Mfg. Co.									
Saginaw, Saginaw Co., A. T. 585 ±, D. 710+ ? Wylie Well.									
Midland, Midland Co., A. T. 590 ±, D. 1,200 ?									
Mt. Pleasant, Isabella Co., A. T. 770, D. 1,555									
Alma, Gratiot Co., A. T. 740 ±, D. 2,861		2,620	2,861+						

REFERENCE TABLE OF DEEP BORINGS IN MICHIGAN BY DISTRICTS, SHOWING DEPTH, THICKNESS AND PROVISIONAL CORRELATIONS OF THE VARIOUS FORMATIONS.

Central Michigan.	Berea grit or sandstone, white or gray, coarse and full of pure strong brine. "Third brine." Oil and gas horizon.	Antrim Black Shale—Upper part blue; sandstone lenses. Signs of oil and gas.	Traverse Formation—Top generally limestone; middle, limestone and shale; bottom, blue or black shale.	Dundee Limestone—Consistently a limestone. Oil and gas horizon.	Upper Monroe—Dolomites or "limestones." Gypsum or anhydrite, celestite and sulphur.	Middle Monroe or Sylvania—Pure white sandstone, friable and passing into sand and limestone toward the north.	Lower Monroe or Bass Island—Dolomites or "limestones," often sandy, cherty; anhydrite and celestite.	Salina—Salt, anhydrite or "gypsum," dolomites or "limestones," red, green or black shales.	Guelph and Niagara—White dolomites or "limestones," often cherty.
Ithaca, Gratiot Co., A. T. 680 ±, D. 613									
Owosso, Shiawassee Co., A. T. 745, D. 1,100+ G. W. Collyer Well, 4 miles west of city.									
Corunna, Shiawassee Co., A. T. 776, D. 907 Corunna Coal Co.									
Grand Rapids, Kent Co., A. T. 605 ±, D. 2,220 Grand Rapids Artesian Water Co.		1,708	1,885				2,220 ?	2,220 ?	
Charlotte, A. T. 906, D. 2,209 E. Shepherd and F. W. Higby.	1,700	1,930	1,985	2,105	2,209+				
Jackson, A. T. 928, D. 2,455 Worthington & Cooley Mfg. Co.	1,465	1,655	1,770	1,870			2,485+		
Northern Part of Lower Peninsula.									
Cheboygan, Cheboygan Co., A. T. 590+, D. 2,725							1,550	1,550 ?	2,050
Grayling, Crawford Co., A. T. 1,140, D. 2,750 Salling, Hanson & Co.		2,165	2,750						
Alpena, Alpena Co., A. T. ....., D. 1,712 Alpena Land Co. No. 1 at Grand Lake.			100	265	700	800	1,352	1,712	
Alpena, Alpena Co., A. T. ?, D. 1,638 U. S. Geol. Surv. Well.					450	535 ?	1,315 ±	1,638+	
Grayling, Crawford Co., A. T. 1,140, D. 2,280? Grayling No. 2.		2,280							
Harrisville, Alcona Co., A. T. 640, D. 506+?	506								

Killmaster, Alcona Co., A. T. 670, D. 1,530	610	1,000 ?	1,530?+	....	....	....	....	....	....
Upper Peninsula.									
Rapid River, Delta Co., A. T. 650±, D. 800+200	....	....	....	....	....	....	....	....	....
A. E. Neff, 7 miles northeast Rapid River.									
Gladstone, Delta Co., A. T., 605, D. 743	....	....	....	....	....	....	....	....	....
St. Paul, Sault Ste. Marie R. R.									
Escanaba, Delta Co., A. T., 600, D ...?	....	....	....	....	....	....	....	....	....
Wagner Well opposite Escanaba, Sec. 8, T. 39 N., R. 21 W.									
Marinette, Wis., A. T. 600, D. 978	....	....	....	....	....	....	....	....	....
Marinette Water Works.									
Neebish Island, Chippewa Co., A. T. 670±, D. 527+	....	....	....	....	....	....	....	....	....
American Alkali Co.									
Pickford, Chippewa Co., A. T. 670, D. 1,425-1,500	....	....	....	....	....	....	....	....	260
Taylor, Holden & Van Campen.									
St. Ignace, Mackinaw Co., A. T. 600±, D. 1,166	....	....	....	....	....	....	....	510	1,020

REFERENCE TABLE OF DEEP BORINGS IN MICHIGAN BY DISTRICTS, SHOWING DEPTH, THICKNESS, AND PROVISIONAL CORRELATIONS OF THE VARIOUS FORMATIONS.

Southeastern District and Port Huron Field.	Rochester shale; Clinton—Limestone and red shales. Medina—Red shales, sometimes sandy or green shales.	Richmond—Red and blue shales, sandy. Lorraine—Blue shales with black streaks toward base.	Utica—Black shales.	Trenton—Dolomite and limestone, blue and shaly, or solid shale at base.	St. Peters—White friable sandstone, often represented by red clay.	Calciferous or Lower Magnesian sandy lime-rock.	Potsdam or Lake Superior sandstone. Red, brown, and striped sandstones. White upper strata. Water.	Pre-Cambrian.	
Monroe, Monroe Co., A. T. 579±, H. D. 1,765. Moore Well.	1,150	1,570	1,734	1,765					
Blissfield, Lenawee Co., A. T. ...., D. 2,402. Sec. 30, T. 7, S. R. 5 E.			2,340	2,402+					
Adrian, Lenawee Co., A. T. 810, H. D. 1,650. Adrian Gas Co.		1,650							
Dundee, Monroe Co., A. T. 670±, D. 1,473.	1,503								
Manchester, Washtenaw Co., A. T. 830±, D. 690. Manchester Oil Co. 6 miles southeast of town.									
Britton, Lenawee Co., A. T. 700±, D. 1,603+									
Wyandotte, Wayne Co., A. T. 580, D. 2,502	2,210	2,500+							
Milan, Washtenaw Co., A. T. 685, D. 1,643									
Ypsilanti. Washtenaw Co., A. T. 682, D. 1,210. Banner Oil & Gas Co.									
Ann Arbor, Washtenaw Co., A. T. 875, D. 1,326									
Romulus, Wayne Co., A. T. 620, D. 1,820. E. Twark well, 6 miles northeast of Ecorse.									
Detroit, Wayne Co., A. T. 587+, D. 2,097. Stroh's Brewery.									
Ecorse, Wayne Co., A. T. 587±, D. 1,323. Morton Salt Co.									

Algonac, St. Clair Co., A. T. 590, D. 1,727									
A. Miller, 5 miles below town.									
Marine City, St. Clair Co., A. T. 600, D. 1,630									
National Salt Co.									
Marine City, St. Clair Co., A. T. 600 ±, D. 1,641									
Lester & Roberts.									
Mt. Clemens, Macomb Co., A. T. 617, D. 1,060									
Romeo, Macomb Co., A. T. 755? D. 1,575									
Village well.									
Pontiac, Oakland Co., A. T. 934, D. 1,505									
Pontiac Natural Gas and Oil Co.									
Royal Oak, Oakland Co., A. T. ?, D. 2,502									
Royal Oak Manufacturing & Gas Co.									
New Baltimore, St. Clair Co., A. T. ?, D. 1,640									
St. Clair, St. Clair Co., A. T. 600 ±, D. 1,807									
Diamond Crystal Salt Co.									
St. Clair, St. Clair Co., A. T. 600?, D. 1,682?									
St. Clair Salt Works.									
Marysville, St. Clair Co., A. T. 600, D. 1,150									
Binic Farm.									
Port Huron, St. Clair Co., A. T. 605, D. 668									
Bailey No. 1.									
Port Huron, St. Clair Co., A. T. 605 +, D. 680 +									
Sec. 9, T. 6 N., R. 17 E. G. B. Stock wells.									
Port Huron, St. Clair Co., A. T. 623, D. 772									
Grand Trunk Jc. well.									
Port Huron, St. Clair Co., A. T. 633-589, D. 1,685 +									
F. L. Wells "Bore Hole."									
Imlay City, Lapeer Co., A. T. 830, D. 1,026									
Walker & Co.									
Port Huron, St. Clair Co., A. T. 655, D. 833									
Beard well, 10 miles northwest Port Huron.									
Valley Center, Sanilac Co., A. T. 805, D. 876									
Petrolia, Ontario, A. T. 667, D. 1,505									
"Test Well."									
Wallaceburg, Ontario, D. 2,100									
Ten miles southeast Pt. Lambton.									
Southwestern District.									
Bridgman, Berrien Co., A. T. 636, D. 768									
Bridgman Oil and Gas Co.									
Niles, Berrien Co., A. T. 681, D. 1,099 (1,140?)									

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Southeastern District.	Rochester shale; Clinton—Limestone and red shales. Medina—Red shales, sometimes sandy or green shales.	Richmond—Red and blue shales, sandy. Lorraine—Blue shales with black streaks toward base.	Utica—Black shales.	Trenton—Dolomite and limestone, blue and shaly, or solid shale at base.	St. Peters—White friable sandstone, often represented by red clay.	Calciferous or Lower Magnesian sandy lime-rock.	Potsdam or Lake Superior sandstone. Red, brown, and striped sandstones. White upper strata. Water.	Pre-Cambrian.	
Niles, Berrien Co., A. T. 681 +, D. 592. Niles Oil and Gas Co.									
Berrien Springs, Berrien Co., A. T. 650 ±, D. 700									
Dowagiac, Cass Co., A. T. 760, D. 1,760. Round Oak Gas & Fuel Co.	1,760	?							
Benton Harbor, Berrien Co., A. T. 600, D. 1,205. Benton Harbor Natural Gas & Oil Co.									
Allegan, Allegan Co., A. T. 708, D. 1,400. Allegan Oil & Gas Co.									
Goshen, Ind., A. T. 789, D. 2,054		1,597	1,812	2,054 ?					
South Bend, Ind., A. T. 725, D. 1,670		1,400	1,585	1,670+					
Elkhart, Ind., A. T. 755 or 741, D. 615									
White Pigeon, St. Joseph Co., A. T. ?, D. 763. White Pigeon Oil & Gas Co.									
Constantine, St. Joseph Co., A. T. 803, D. 1,080									
Coldwater, Branch Co., A. T. 983, D. 1,200									
Kalamazoo, Kalamazoo Co., A. T. 777, D. 2,250. Kalamazoo Natural Gas Co.	2,250+								

Assyria, Barry Co., A. T. 917, D. 2,040+ ?										
Western Michigan.										
Muskegon, Muskegon Co., A. T. 594, D. 2,627 Mason well near Occidental Hotel.										
Muskegon, Muskegon Co., A. T. 588, D. 2,050-2,200 (?) Ryerson Hill well.										
Muskegon, Muskegon Co., A. T. 592, D. 1,500 Michigan Oil Co. 40 ft. from Mason.										
Muskegon, Muskegon Co., A. T. 592 ±, D. 1,650 Central Paper Co., N. E. ¼ Sec. 34, T. 10 N., R. 17 W.										
Ludington, Mason Co., A. T. 590, D. 2,304 Stearns Lumber and Salt Co. Well.										
Ludington, Mason Co., A. T. 590, D. 2.220 Pere Marquette Lumber Co.										
Ludington, Mason Co., A. T. 600, D. 2,260 Butters & Peters well, 1 mile south of Pere Marquette well.										
Manistee, Manistee Co., A. T. 604, D. 1,947 + 500 ± Canfield-Wheeler.										
Manistee, Manistee Co., A. T. 590 ±, D. 2,206 R. G. Peters Well.										
Manistee, Manistee Co., A. T. 610 D, 2015 Buckley & Douglass Lumber Co. No. 5.										
Stronach, Manistee Co., A. T. 604, D. 1,972 Stronach Lumber Co.										
Frankfort, Benzie Co., A. T. 600 +, D. 1,800 A. G. Butler.										
Central Michigan.										
Caseville, Huron Co., A. T. 590?, D. 3,230										
Bay City, Bay Co., A. T. 590, D. 2,865 Atlantic Mill in North Bay City.										
South Bay City, Bay Co., A. T. 592 ±, D. 3,508 North American Chemical Co. "Rock Salt" Well.										
Saginaw, Saginaw Co., A. T. 600, D. 900 Saginaw Plate Glass Co., Saginaw Town.										
East Saginaw, Saginaw Co., A. T. 588, D. 800 East Saginaw Salt & Mfg. Co.										
Saginaw, Saginaw Co., A. T. 585 ±, D. 710+ ? Wylie Well.										
Midland, Midland Co., A. T. 590 ±, D. 1,200 ?										
Mt. Pleasant, Isabella Co., A. T. 770, D. 1,555										
Alma, Gratiot Co., A. T. 740 ±, D. 2,861										

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Central Michigan.	Rochester shale; Clinton—Limestone and red shales. Medina—Red shales, sometimes sandy or green shales.	Richmond—Red and blue shales, sandy. Lorraine—Blue shales with black streaks toward base.	Utica—Black shales.	Trenton—Dolomite and limestone, blue and shaly or solid shale at base.	St. Peters—White friable sandstone, often represented by red clay.	Calciferous or Lower Magnesian sandy lime-rock.	Potsdam or Lake Superior sandstone. Red, brown, and striped sandstones. White upper strata. Water.	Pre-Cambrian.	
Ithaca, Gratiot Co., A. T. 680 ±, D. 613									
Owosso, Shiawassee Co., A. T. 745, D. 1,100+ G. W. Collyer Well, 4 miles west of city.									
Corunna, Shiawassee Co., A. T. 776, D. 907 Corunna Coal Co.									
Grand Rapids, Kent Co., A. T. 605 ±, D. 2,220 Grand Rapids Artesian Water Co.									
Charlotte, A. T. 906, D. 2,209 E. Shepherd and F. W. Higby.									
Jackson, A. T. 928, D. 2,455 Worthington & Cooley Mfg. Co.									
Northern Part of Lower Peninsula.									
Cheboygan, Cheboygan Co., A. T. 590+, D. 2,725	2,725	2,725 ?							
Grayling, Crawford Co., A. T. 1,140, D. 2,750, Salling, Hanson & Co.									
Alpena, Alpena Co., A. T. ....., D. 1,712 Alpena Land Co. No. 1 at Grand Lake.									
Alpena, Alpena Co., A. T. ?, D. 1,638 U. S. Geol. Surv. Well.									
Grayling, Crawford Co., A. T. 1,140, D. 2,280? Grayling No. 2.									
Harrisville, Alcona Co., A. T. 640, D. 506+?									

Killmaster, Alcona Co., A. T. 670, D. 1,530									
Upper Peninsula.									
Rapid River, Delta Co., A. T. 650 ±, D. 800+200 A. E. Neff, 7 miles northeast Rapid River.				290 ?	320	555	830	1,000+	
Gladstone, Delta Co., A. T., 605, D. 743 St. Paul, Sault Ste. Marie R. R.				326	404	642	743	743 ?	
Escanaba, Delta Co., A. T., 600, D Wagner Well opposite Escanaba, Sec. 8, T. 39 N., R. 21 W.		201	251	640					
Marinette, Wis., A. T. 600, D. 978 Marinette Water Works.				325	400	580	870 ±	978+	
Neebish Island, Chippewa Co., A. T. 670 ±, D. 527+ American Alkali Co.				158	211 ?	223 ?	527+		
Pickford, Chippewa Co., A. T. 670, D. 1,425-1,500 Taylor, Holden & Van Campen.		475	525	600–700	800–900	?	1,500		
St. Ignace, Mackinaw Co., A. T. 600 ±, D. 1,166	1,166+								

DIRECTORY OF THE MINERAL PRODUCERS OF MICHIGAN

Compiled by the Michigan Geological and Biological Survey in cooperation with the United States Geological Survey, Division of Mineral Resources.

LIST OF COPPER MINING COMPANIES, ADDRESS OF HEAD OFFICE AND NAME OF PERSON IN CHARGE OF PROPERTY.

Adventure Consolidated Copper Co., 32 Broadway, N. Y., Chas. L. Lawton, General Superintendent.

Ahmeek Mining Company, 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.

Agate Harbor Mine, care of Mrs. Anna Scott Block, 100 Washington St., Chicago.

Algomah Mining Co., 60 State St., Boston, Mass., R. M. Edwards, General Manager.

Allouez Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.

Arnold Mining Co., 64-50 State St., Boston, Mass., Capt. Wesley Clark, Superintendent.

Ashbed Mining Co., 64-50 State St., Boston, Mass., Capt. Wesley Clark, Superintendent.

Atlantic Mining Co., 82 Devonshire Place, Boston, Mass., F. W. Denton, General Manager.

Baltic Mining Co., 82 Devonshire Place, Boston, Mass., F. W. Denton. General Manager.

Bohemia Mining Co., 85 Devonshire Place, Boston, Mass., R. M. Edwards, Superintendent.

Boston & Lake Superior Mineral Land Co., Houghton, F. W. Nichols, Agent.

Calumet & Hecla Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.

Carp Lake Mining Co., Ontonagon, H. L. Payne, General Manager.

Centennial Copper Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.

Champion Copper Co., 82 Devonshire St., Boston, Mass., F. W. Denton, General Manager.

Cherokee Copper Co., Houghton, R. M. Edwards, H. W. Fesing.

Clark Mine, Dr. Leon Estivant, 47 Ave. de' Alma, Paris, France, F. W. Nichols, Agent.

Cliff Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.

Contact Copper Co., 70 State St., Boston, Mass., Geo. Goodale, Superintendent.

Copper Crown Mining Co. of Michigan, 1013 Eastern Ave., St. Louis, Jacob Maurer, President.

Copper Range Co., 82 Devonshire St., Boston, F. W. Denton, General Manager.
Dakota Heights Co., Hancock, H. L. Baer, President.
Dana Copper Co., 68 Devonshire St., Boston, James MacNaughton, General Manager.
Elm River Copper Co., 70 State St., Boston, Geo. S. Goodale, Superintendent.
Franklin Mining Co., 60 Congress St., Boston, R. M. Edwards, Superintendent.
Frontenac Copper Co., 12 Ashburton Place, Boston, James MacNaughton, General Manager.
Globe Mine, care of J. R. Stanton, 15 William St., N. Y., Thos. Dengler, Superintendent, Painesdale.
Gratiot Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Hancock Consolidated Mining Co., Hancock, John L. Harris, Superintendent.
Home Copper Mining Co., Copper Falls, Mich.
Houghton Copper Company, 713-199 Washington St., Boston, L. L. Hubbard, General Manager.
Hulbert Mining Co., 199 Washington St., Boston, Mass., F. W. Nichols, Agent.
Humboldt Copper Co., 64-50 State St., Boston, Capt. Wesley Clark, Superintendent.
Indiana Mining Co., 60 Congress St., Boston, R. M. Edwards, General Manager.
Island Copper Co., 1400 Alworth Bldg., Duluth, Minn., F. W. Nichols, Secretary.
Isle Royale Copper Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Keweenaw Association, 33-87 Milk St., Boston, Mass., J. M. Longyear, Agent.
Keweenaw Copper Co., Hancock, Mich., Capt. Thos. Hoatson, Mining Director.
King Phillip Copper Co., 701-199 Washington St., Boston, L. L. Hubbard, Manager.
Lake Copper Co., 85 Devonshire St., Boston, Mass., C. K. Hitchcock, Superintendent.
Lake Milling, Smelting and Refining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Lake Shore Mining Co., 990 West Kensington Road, Los Angeles, W. H. Garlick, President.
Lake Superior Copper Co., Rockland, Mich.
Lake Superior Development Co., Houghton, Mich., Jos. Croze, President.
Lake Superior Smelting Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
LaSalle Copper Company, 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Laurium Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Manitou Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Mass Consolidated Mining Co., 804-79 Milk St., Boston, Mass., E. W. Walker, Superintendent.
Mayflower Mining Co., 70 State St., Boston, Mass., Geo. Goodale, Superintendent.
Meadow Mining Co., 50 State St., Boston, Mass., Capt. Wesley Clark, Agent.
Michigan Copper Mining Co., 15 William St., N. Y., Samuel Brady, Superintendent.
Michigan Smelting Co., 82 Devonshire Place, Boston, Mass., F. I. Cairns, Superintendent.
Mohawk Mining Co., 15 William St., N. Y., A. J. Smith, Superintendent.
Mulock Mine, care of R. P. Mulock, Colfax, Ia., J. F. Dreis, Superintendent.
Natick Copper Co., Houghton, F. W. Nichols, Resident Agent.
National Mining Co., 6 Beacon St., Boston, Mass., B. T. Morrison, President.
Native Copper Co., 68 Devonshire Place, Boston, Mass., M. A. O'Neil, President.
New Arcadian Copper Co., Houghton, Robert H. Shields, General Manager.

New Baltic Copper Co., 87 Milk St., Boston, Robt. H. Shields, General Manager.
New York Consolidated Mining Co., Houghton, F. W. Nichols, Resident Agent.
Nonesuch Mine, 78 Prospect Ave., Milwaukee, Wis., A. K. Camp, Owner.
North Lake Mining Co., 60 Congress St., Boston, R. M. Edwards, Superintendent.
Ojibway Mining Co., 14 Alworth Bldg., Duluth, L. L. Hubbard, President.
Old Colony Copper Co., 70 State St., Boston, Mass., Geo. S. Goodale, Superintendent.
Oneco Copper Co., 64-50 State St., Boston, J. L. Harris, General Manager.
Osceola Consolidated Mining Co., 12 Ashburton Place, Boston, Mass., James MacNaughton, General Manager.
Pacific Copper Co., 705-199 Washington St., Boston, F. W. Nichols, Agent.
Phoenix Consolidated Copper Co., Hancock, Capt. Thos. Hoatson, Director.
Quincy Mining Co., 1000-32 Broadway, N. Y., Chas. L. Lawton, General Manager.
Rhode Island Copper Co., 60 Congress St., Boston, R. M. Edwards, Superintendent.
St. Louis Copper Co., 12 Ashburton Place, Boston, Jas. MacNaughton, General Manager.
St. Mary's Canal Mineral Land Co., 705-199 Washington St., Boston, F. W. Nichols, Resident Agent.
Section Twelve Exploration Co., Hancock, W. A. Burritt, Manager.
Seneca Mining Co., 12 Ashburton Place, Boston, James MacNaughton, General Manager.
Senter-Dupee Development Co., Calumet, Capt. Thos. Hoatson, Manager.
Shelden & Columbian Mine, Houghton, J. H. Rice.
South Lake Mining Co., 68 Devonshire St., Boston, L. L. Hubbard, Manager.
South Range Mining Co., 199 Washington St., Boston, F. W. Nichols, Agent.
South Side Mining Co., 14-68 Devonshire Place, Boston, F. W. Nichols, Agent.
Superior Copper Co., 12 Ashburton Place, Boston, Jas. MacNaughton, General Manager.
Tamarack Mining Co., 12 Ashburton Place, Boston, Jas. MacNaughton, General Manager.
Toltec Mine, care Alfred Meads & Sons, Marquette, Mich.
Torch Lake Mining Co., 5-19 Exchange Place, Boston, F. W. Nichols, Agent.
Tremont & Devon Mining Co., Ltd., Hancock, Hon. Chas. Smith, President.
Trimountain Mining Co., 82 Devonshire St., Boston, F. W. Denton, General Manager.
Union Copper Land and Mining Co., 70 State St., Boston, Geo. Goodale, Superintendent.
Victoria Copper Mining Co., 512-60 Congress St., Boston, Geo. Hooper, Superintendent.
Washington Copper Mining Co., Hancock, Capt. Thos. Hoatson, Director.
West Minnesota Mining Co., 14-68 Devonshire St., Boston, F. H. Whitman, President.
Whealkate Mining Co., Houghton, N. F. Leopold, President.
White Pine Copper Co., 12 Ashburton Place, Boston, Jas. MacNaughton, General Manager.
Wilmot Mining Co., Calumet, W. H. Garlick, President.
Winona Copper Co., 713-199 Washington St., Boston, L. L. Hubbard, General Manager.
Wolverine Copper Mining Co., 15 William St., N. Y., Fred Smith, Superintendent.
Wyandot Copper Co., 68 Devonshire St., Boston, F. L. Van Orden, Manager.

PRODUCERS OF IRON ORE.

Operator.	Office.	Name of mine.	Location of mine.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Michigan	Amasa.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Champion	Beacon.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Tilden	Bessemer.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Columbia	Bessemer.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Hilltop	Bessemer.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Hope	Bessemer.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Mansfield	Bessemer.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Chapin & Cuff	Crystal Falls.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Cottrell	Iron Mt.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Isabella	Iron Mt.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Riverton Grp.	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Dober	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Iron River	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Stambaugh	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Aurora	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Davis	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Geneva	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Puritan	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Royal	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Vaughn (part of Aurora)	Iron River.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Norrie Grp.	Ironwood.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Norrie E.	Ironwood.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Norrie N.	Ironwood.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Norrie	Ironwood.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Pabst	Ironwood.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Lake Superior & Winthrop	Ishpeming
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Hartford	
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Queen Grp.	Negaunee.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Blue	Negaunee.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Buffalo	Negaunee.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Prince of Wales	Negaunee.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	S. Buffalo.	Negaunee.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Aragon & Forest	Norway.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Moore	Palmer.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Cundy	Quinnesec.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Stegmiller	Swanzy.
Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.	Chicago	Wakefield.
Pickands, Mather & Co.	Cleveland, O.		
Hemlock River Mining Co.		Hemlock	Amasa.
Verona Mining Co.		Mikado	Bessemer.
Verona Mining Co.		Vivian	Quinnesec.
Verona Mining Co.		Baltic & Caspian	Stambaugh.
Calumet Ore Co.		Calumet	Felch.

PRODUCERS OF IRON ORE—*Continued.*

Operator.	Office.	Name of mine.	Location of mine.
Brotherton Iron Min-Mining Co		Brotherton & Pike	Wakefield.
Sunday Lake Iron Co		Sunday Lake	Wakefield.
Roger-Brown Ore Co	1515 Corn Exchange Bank Bldg., Chicago, Ill	Gibson	Amasa.
Corrigan, McKinney & Co., Agts	Cleveland, O		
Colby Iron Mining Co	Wickliffe, O	Colby & Ironton	Bessemer.
Crystal Falls Iron Mining Co	Wickliffe, O	Armenia	Bessemer.
Crystal Falls Iron Mining Co	Wickliffe, O	Crystal Falls	Bessemer.
Crystal Falls Iron Mining Co	Wickliffe, O	Dunn	Bessemer.
Crystal Falls Iron Mining Co	Wickliffe, O	Fairbanks	Bessemer.
Crystal Falls Iron Mining Co	Wickliffe, O	Kimball	Crystal Falls.
Crystal Falls Iron Mining Co	Wickliffe, O	Star West	Palmer.
Crystal Falls Iron Mining Co	Wickliffe, O	Baker	Palmer.
Crystal Falls Iron Mining Co	Wickliffe, O	Blair	Palmer.
Crystal Falls Iron Mining Co	Wickliffe, O	Michaels & Tully	Stambaugh.
Genesee Iron Mining Co		Genesee	Crystal Falls.
Great Western Mining Co	Wickliffe, O	Great Western	Crystal Falls.
Lincoln Iron Mining Co		Lincoln	Crystal Falls.
Tobin Iron Mining Co	Wickliffe, O	Tobin	Crystal Falls.
Quinnesec Iron Mining Co		Quinnesec	Quinnesec.
E. N. Breitung & Co		Lamont	Crystal Falls.
Dunn Iron Mining Co	Colby-Abbot Bldg., Milwaukee, Wis	Palms	Bessemer.
Lake Superior Iron & Chem. Co	Penobscot Bldg., Detroit	Yale	Bessemer.
Newport Mining Co	Colby-Abbot Bldg., Milwaukee, Wis	Anvil	Bessemer.
Newport Mining Co	Colby-Abbot Bldg., Milwaukee, Wis	Newport	Ironwood.
Hollister Mining Co	Perry-Payne Bldg., Cleveland, O	Hollister	Crystal Falls.
M. A. Hanna & Co	Perry-Payne Bldg., Cleveland, O	Hollister	Crystal Falls.
Oglebay, Norton & Co	Wade Bldg., Cleveland, O	Hollister	Crystal Falls.
Bristol Mining Co	Wade Bldg., Cleveland, O	Bristol	Crystal Falls.
Antoine Ore Co	Wade Bldg., Cleveland, O	Clifford & Traders	Crystal Falls.
Antoine Ore Co	Wade Bldg., Cleveland, O	Keel Ridge	Iron Mt.

PRODUCERS OF IRON ORE—*Continued.*

Operator.	Office.	Name of mine.	Location of mine.
Brule Mining Co.	Wade Bldg., Cleveland, O.	Chatham	Iron River.
Brule Mining Co.	Wade Bldg., Cleveland, O.	Berkshire.	Stambaugh.
Empire Iron Co	Chicago, Ill	Empire.	Palmer.
Castile Mining Co.	Chicago, Ill	Asteroid & Eureka.	Ramsey.
Castile Mining Co.	Chicago, Ill	Castile	Wakefield.
Wisconsin Steel Co.	Harvester Bldg., Chicago, Ill	Lot No. 3.	Crystal Falls.
American-Boston Mining Co.	Cleveland, O	American-Boston	Diorite.
M. A. Hanna & Co.	Cleveland, O	American-Boston	Diorite.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Northwestern	Gwinn.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Smith	Gwinn.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Austin	Gwinn.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Princeton.	Gwinn.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Stephenson	Gwinn.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Ashland	Ironwood.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Cleveland.	Ironwood.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Lake	Ironwood.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Cliff Shaft.	Ironwood.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Moro	Ironwood.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Ogden.	
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Salisbury	Ishpeming.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Imperial & Webster.	Michigamme.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Jackson	Negaunee.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Maas	Negaunee.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Lucy	Negaunee.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Negaunee.	Negaunee.
Washington Iron Co	Savings Bank Bldg., Marquette	Barron & Franklin.	Humboldt.
Dessau Mining Co.	Iron Mountain	Millie	Iron Mt.

PRODUCERS OF IRON ORE—*Continued.*

Operator.	Office.	Name of mine.	Location of mine.
Pewabic Company	912 Wells Bldg., Milwaukee, Wis.	Pewabic & Walpole	Iron Mt.
Bates Iron Co	25 Broad St., New York, N. Y.	Bates	Iron River.
Davidson Ore Mining Co	Buffalo, N. Y	Davidson No. 1	Iron River.
Davidson Ore Mining Co	Buffalo, N. Y	Davidson No 2	Iron River.
Huron Iron Mining Co.	1314 Rockefeller Bldg., Cleveland, O.	Youngs	Iron River.
Mineral Mining Co	912 Wells Bldg., Milwaukee, Wis.	Osana	Iron River.
Mineral Mining Co	912 Wells Bldg., Milwaukee, Wis.	Wauseca.	
Mineral Mining Co	912 Wells Bldg., Milwaukee, Wis.	Nanaimo	Iron River.
Mineral Mining Co	912 Wells Bldg., Milwaukee, Wis.	Breen	Waucedah.
Munro Iron Mining Co.	57 Erie County Bank Bldg., Buffalo, N. Y	Chicagon	Iron River.
Munro Iron Mining Co.	57 Erie County Bank Bldg., Buffalo, N. Y	Hiawatha	Iron River.
Munro Iron Mining Co.	57 Erie County Bank Bldg., Buffalo, N. Y	Saginaw	Ishpeming.
Munro Iron Mining Co.	57 Erie County Bank Bldg., Buffalo, N. Y	Munro	Norway.
Spring Valley Iron Co.	Wellston, O. (or Iron River).	Zimmerman	Iron River.
Pittsburg & Lake Angeline Iron Co	Cleveland, O.	Lake Angeline.	
Pittsburg & Lake Angeline Iron Co	Cleveland, O.	Mitchell	Ishpeming.
Loretto Iron Co	1400 Fulton St., Chicago, Ill.	Appleton (or Eleanor)	Loretto.
Loretto Iron Co	1400 Fulton St., Chicago, Ill.	Loretto	Loretto.
Niagara Iron Mining Co	Iron River	Ohio & Portland	Michigamme.
Breitung Hematite Mining Co., Ltd.	Savings Bank Bldg., Marquette	Breitung	Negaunee.
Breitung Hematite Mining Co	Savings Bank Bldg., Marquette	Hematite No. 1 & 2.	Negaunee.
Jones & Laughlin Ore Co	3rd Ave. & Ross St., Pittsburgh, Pa.	Rolling Mill.	Negaunee.
Mary Charlotte Mining Co	Savings Bank Bldg., Marquette	Mary Charlotte No. 1 & No. 2.	Negaunee.

PRODUCERS OF IRON ORE—*Concluded.*

Operator.	Office.	Name of mine.	Location of mine.
Republic Iron & Steel Co.	Oliver Bldg., Pittsburgh, Pa	Cambria & Lillie	Negaunee.
Richmond Iron Co.	Perry-Payne Bldg., Cleveland, O.	Richmond	Palmer.
Volunteer Ore Co.	1400 Alworth Bldg., Duluth, Minn.	Volunteer	Palmer.
Michigan Iron Mining Co.	Iron River	Corry	Palatka.
Michigan Iron Mining Co.	Iron River	Cyr	Stambaugh.
Republic Iron Co.	1703 Morris Bldg., Phila, Pa.	Republic & W. Republic	Republic.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Penn Mines	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Brier Hill	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Cyclops	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Curry	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Norway	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila,. Pa	Vulcan	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Vulcan E.	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Vulcan S. E.	Vulcan.
Penn Iron Mining Co.	1703 Morris Bldg., Phila., Pa	Vulcan W.	Vulcan.
Catherine Mining & Exploration Co.	Michigamme; Pittsburg, Pa.		Spurr Twp.
McGreevy Iron Co.	Iron River		Iron County.
Wickwire Mining Co.	Iron River	Wickwire	Iron River.
Iron River Steel Co.	Iron River	Michigan & Lennox	Iron River.
Iron River Ore Co.	Iron River		Iron River.
McDonald Mining Co.		McDonald	Crystal Falls.

PRODUCERS OF MANGANIFEROUS IRON ORE.

Operator.	Office.	Name of mine.	Location of mine.
Oglebay, Norton & Co.	Wade Bldg., Cleveland, O.	Bristol	Crystal Falls.
Bristol Mining Co.	Wade Bldg., Cleveland, O.	Bristol	Crystal Falls.
Newport Mining Co.	Colby-Abbot Bldg., Milwaukee, Wis	Newport	Ironwood.
Cleveland Cliffs Iron Co	Rockefeller Bldg., Cleveland, O.	Jackson & Lucy	Negaunee.

PRODUCERS OF MINERAL PAINTS, 1911.

Pigment.	Operator.	Office.	Location of plant.
Met. paint...	Huron Valley Consolidated Paint & Oil Co., A. J. Boatwright, Sec. (Not yet operative. Operates in 1912).	24-26 S. Huron St., Ypsilanti..	Belleville.
White lead....	Acme White Lead & Color Works...	Detroit.........	Detroit.
Met. paint...	Pickands, Mather & Co.......... (Hemlock Mine)	Cleveland, Ohio..	Iron county.

BLAST FURNACES IN MICHIGAN.

Name of furnace.	Name of company.	Location of furnace.
Antrim........	Antrim Iron Company..................	Antrim.
Cadillac........	Mitchell-Diggins Iron Co................	Cadillac.
Carp...........	Pioneer Iron Company................	Near Marquette.
Chocolay.......	Lake Superior Iron & Chem. Co.........	Harvey.
Detroit........	Detroit Furnace Company..............	Detroit.
East Jordan....	East Jordan Furnace Company..........	East Jordan.
Elk Rapids.....	Lake Superior Iron & Chem. Co.........	Elk Rapids.
Gladstone......	Pioneer Iron Company................	Gladstone.
Manistique.....	Lake Superior Iron & Chem. Co.........	Manistique.
Marquette......	Pioneer Iron Company................	Marquette.
Newberry......	Lake Superior Iron & Chem. Co.........	Newberry.
Pine Lake......	Lake Superior Iron & Chem. Co.........	Boyne City.
Spring Lake....	Spring Lake Iron Company.............	Fruitport.
Stevenson......	Stevenson Charcoal Iron Co.............	Wells.
Zug Island A...	Detroit Iron & Steel Company...........	Detroit.
Zug Island B...	Detroit Iron & Steel Company...........	Detroit.

LOCAL COMMERCIAL COAL MINES, 1911.

Operator.	Office.	Name of mine.	County.
Beaver Coal Co.	Bay City	Beaver	Bay.
Handy Bros. Mining Co	Bay City	Monitor	Bay.
Michigan Coal & Mining Co	Bay City	Michigan	Bay.
Robert Gage Coal Co.	Bay City	Nos. 5, 6 & 7	Bay.
What Cheer Coal Mining Co	Bay City	What Cheer	Bay.
Central Coal Mining Co.	Saginaw	Central	Bay.
Wolverine, Nos. 2 and 3	Saginaw	Wolverine Nos. 2 & 3	Bay.
Royal Coal Co.	Bay City		Bay.
A. B. Schumaker	Grand Ledge	Schumaker	Eaton.
American Sewer Pipe Co.	Akron, Ohio		Eaton.
Genesee Coal Mining Co	Flint	Genesee	Genesee.
Robert Gage Coal Co.	Bay City	Nos. 1, 2, 3 & 4	Saginaw.
Barnard Coal Co.	Saginaw	Barnard	Saginaw.
Buena Vista Coal Co.	Saginaw	Buena Vista	Saginaw.
Caledonia Coal Co. (Ltd.)	Saginaw	Caledonia No. 2	Saginaw.
Consumers Coal Co.	Saginaw		Saginaw.
The Northern Coal & Transportation Co	Saginaw	Northern	Saginaw.
Pere Marquette Coal Co	Saginaw	Pere Marquette No. 3	Saginaw.
Riverside Coal Co.	Saginaw	Riverside	Saginaw.
Saginaw Coal Co.	Saginaw	Saginaw	Saginaw.
Shiawassee Coal Co	Saginaw	Shiawassee	Saginaw.
Uncle Henry Coal Co.	Saginaw	Uncle Henry	Saginaw.
Bliss Coal Co.	Swan Creek	Swan Creek	Saginaw.
Nond Kean Coal Mining Co.	Owosso		Shiawassee.
Detroit Vitrified Brick Co.	Corunna	Peak	Shiawassee.
Handy Bros. Mining Co	Bay City	Akron	Tuscola.

(Mines producing less than 3000 and more than 1000 tons per annum, or employing less than 10 men.)

Operator.	Office.	County.
F. L. Reed (Frank Hazel)	Grand Ledge	Clinton.
Grand Ledge Clay Product Co	Grand Ledge	Eaton.
C. H. Pickens	Grand Ledge	Eaton.
T. W. Jenkins	Williamston	Ingham.
Carbon Coal Co	Saginaw	Saginaw.

COKE PRODUCERS, 1911.

Operators.	Address.	Location or name of mine.	No. of oven.	County.
Michigan Alkali Co.....	Wyandotte.....	Plant No. 2...	a30......	Wayne.
Solvay Process Co...... (Semet-Solvay Co.)	Syracuse, N. Y..	Detroit.......	b132.....	Wayne.

PRODUCERS OF GYPSUM PRODUCTS, 1911.

Operator.	Office.	Name of plant.	Location of mine.
United States Gypsum Co..	Chicago, Ill.....	Alabaster.......	Alabaster.
United States Gypsum Co..	Chicago, Ill.....	Midland.........	Grand Rapids.
Acme Cement Plaster Co..	St. Louis, Mo...	Mill No. 5......	Beverly.
Michigan Gypsum Co......	Grand Rapids...	....	Grand Rapids.
American Cement Plaster Co....................	Lawrence, Kans.	Grand Rapids...	Grand Rapids.
Grand Rapids Plaster Co..	429 Mich. Trust Bldg., Grand Rapids.......	Eagle Mill......	Grand Rapids.
Grand Rapids Plaster Co..	429 Mich. Trust Bldg., Grand Rapids.......	Grandville......	Grandville.
Gypsum Products Mfg. Co.	44 Powers Theater Bldg., Grand Rapids.	Powers Plaster Mill..........	Grand Rapids.

SALT PRODUCERS, 1911.

Operators.	Office.	Works.
Bay County:		
The Mershon-Bacon Co	Bay City	Bay City.
Hine Lumber Co	Sta. A., Bay City, W. S	West Bay City.
Gratiot County:		
St. Louis Chem. Co. (Also Bromine).	St. Louis	St. Louis.
Manistee County:		
The R. G. Peters Salt & Lumber Co.	East Lake	East Lake.
Filer & Sons, Vacuum Pan Salt Works	Filer City	Filer ity.
The Buckley & Douglass Lumber Co.	381 River St., Manistee	Manistee.
Louis Sands Salt & Lumber Co.	Manistee	Manistee.
Mason County:		
Anchor Salt Co	Ludington	Ludington.
The Stearns Salt & Lumber Co.	Washington Ave., Ludington	Ludington.
Saginaw County:		
Mershon, Eddy, Parker & Co	Saginaw	Carrollton.
Bliss & Van Auken	Saginaw, W. S	Saginaw.
S. L. Eastman Flooring Co	Saginaw, W. S	Saginaw.
Edward Germain	Saginaw, E. S	Saginaw.
Saginaw Plate Glass Co (Also Calcium Chloride).	Saginaw, W. S	Saginaw.
Saginaw Salt Co.	430 Shearer Bldg., Bay City	St. Charles.
Van Schaack Calcium Works (Also Calcium Chloride).	140 Lake St	Mt. Pleasant.
St. Clair County:		
Davidson-Wonsey Co	Marine City	Marine City.
Michigan Salt Works	Marine City	Marine City.
Sicken Salt & Stave Co	Marine City	Marine City.
Port Huron Salt Co.	717 Ry. Ex., Chicago, Ill. (Port Huron)	Port Huron.
Port Huron Salt Co.	717 Ry. Ex., Chicago, Ill. (Port Huron)	St. Clair.
Diamond Crystal Salt Co.	St. Clair	St. Clair.
Wayne County:		
Delray Salt Co.	Detroit	Delray.
Solvay Process Co.	Syracuse, N. Y	Delray.
Detroit Salt Co	Detroit	Detroit.
Peninsular Salt Co.	Ecorse	Ecorse.
Worcester Salt Co	168 Duane St., New York City, N. Y	Ecorse.
Michigan Alkali Co.	Wyandotte	Wyandotte.
Pennsylvania Salt Mfg. Co.	115 Chestnut St., Philadelphia, Pa	Wyandotte.

CEMENT PRODUCERS.

Operator.	Office.	Works.
Alpena Portland Cement Co	Alpena	Alpena.
El Cajou Portland Cement Co	Au Sable	Alpena.
Huron Portland Cement Co	Detroit (1525 Ford Bldg.)	Alpena.
The Hecla Co	Penobscot Bldg., Detroit	Bay City.
Burt Portland Cement Co	Bellevue	Bellevue.
Chanute Cement & Clay Products Co	Bronson	Bronson.
Peninsular Portland Cement Co	Cooley Blk., Jackson	Cement City.
Michigan Portland Cement Co	Chelsea	Chelsea.
Wolverine Portland Cement Co	Coldwater	Coldwater and Quincy.
New Aetna Portland Cement Co	412 Union Tr. Bldg., Detroit	Fenton.
Egyptian Portland Cement Co	712 Union Tr. Bldg., Detroit	Fenton & Holly.
Logan Portland Cement Co	Fenton	Fenton.
Omega Portland Cement Co	Jonesville	Mosherville.
Newaygo Portland Cement Co	Newaygo	Newaygo.
Elk Cement & Lime Co	Elk Rapids	Elk Rapids.
Peerless Portland Cement Co	Union City	Union City.
Wyandotte Portland Cement Co	Wyandotte	Wyandotte.

NATURAL GAS PRODUCERS, 1911.

Operator.	No. of wells.	Address.
Hillsdale County:		
C. M. DeWitt		Osseo.
Macomb County:		
Brozowski, August		Warren, Mich.
Dobberousky, J.		Halfway.
Elwart, Frank		Warren, R. F. D. 2.
Elwart, Jos.		Warren, R. F. D. 2.
Hartsig, Wm. L.		Warren, R. F. D. 2.
Jacob, Otto		Warren, R. F. D. 2.
Jacob, Edw.		Warren, R. F. D. 2.
Mielka, August		Warren, R. F. D. 2.
Haneker, Wm		Warren, R. F. D. 2.
Peters, Alfred		Warren, R. F. D. 2.
Schemue, Louis		North Detroit, R. F. D. 1, Box 47.
Shaak, Chas		Halfway.
Smith, Alex		Warren, R. F. D. 2.
Vohs, Henry		Warren, R. F. D. 2.
Wolgast, Max		Warren, R. F. D. 2.
Muskegon County:		
Boozer, Lawrence		Ravenna, Mich., R. F. D. 2.
Jackson, Robert		Ravenna, R. F. D. 3.
Oakland County:		
N. E. Springsteen		Royal Oak, Mich., R. F. D.
Edwin Starr		Royal Oak, Mich., R. F. D.
Wm. Purdy	4	Redford, Mich., R. F. D.
J. R. McKinley		Redford, Mich., R. F. D.
Henry Langer	2	Redford, Mich., R. F. D.
Edw. McCue? (McHugh)	1	Redford, Mich., R. F. D.
Grank Grosjean	1	Redford, Mich., R. F. D.
Louis Granzow	1	Redford, Mich., R. F. D.
Edw. Landan	1	Redford, Mich., R. F. D.
Wilkinson, Mr. ?	1	Redford, Mich., R. F. D.
St. Clair County:		
Gillett, Lawrence		Port Huron.
Michigan Development Co.		Port Huron.
Wayne County:		
Desgrandchamp, John		No. Detroit.

LIMESTONE PRODUCERS, 1911.

Operators.	Office.	Quarry.
Alpena County:		
R. Collins *Also lime.*	151 Water St., Alpena	Alpena.
Michigan Alkali Co	Wyandotte (or Detroit)	Alpena.
Arenac County:		
Thos. P. Burt *Also lime.*	6001 Gilmore St., Appleton, Wis	Omer.
M. J. Griffin	169 Stanton Ave., Detroit, Mich	Omer.
Bay County:		
Boutell Bros. & Co *Also lime.*	1201 Water St., Bay City.	Bay City.
C. M. Clute *Also lime.*	Bay City	Bay City.
Charlevoix County:		
Elk Cement & Lime Co. Operated by the Northern Lime Co. of Grand Rapids.	Elk Rapids	Bayshore.
Superior Lime Co *Also lime.*	2 First Ave., Grand Rapids	Bayshore.
City of Charlevoix Street Commissioner	Charlevoix	Charlevoix.
Charlevoix Rock Product Co *Also lime.*	Charlevoix	Charlevoix.
Cheboygan County:		
Campbell Stone Co	Afton	Afton.
Chippewa County:		
Drummond Island Stone Co Ludlow Seaman.	Drummond	Drummond.
Delta County:		
Delta Contracting Co	108 N. Charlotte St., Escanaba	Escanaba (Hyde)
A. T. Garland	Escanaba	Escanaba (Hyde)
John Bichler	Groos	Groos.
Emmet County:		
Antrim Lime Co *Also lime.*	912 Mich. Trust Bldg., Grand Rapids	Petoskey.
Michigan Lime Co *Also lime.*	Petoskey	Petoskey.
The Petoskey Stone & Lime Co., L. G. Grimes *Also lime.*	Emmet St., Petoskey	Petoskey.
Huron County:		
Wallace Stone Co	Bayport	Bayport.
Kent County:		
City of Grand Rapids	Grand Rapids	Grand Rapids.

LIMESTONE PRODUCERS—*Concluded.*

Operators.	Office.	Quarry.
Mackinac County:		
Ozark Quarry Co.	Ozark	Ozark.
Union Carbide Co. *Also lime.*	79 Wall St., New York, N. Y.	Rexton.
S. B. Martin Co.	Fiborn Quarry	Fiborn Quarry.
Marquette County:		
F. B. Spear & Sons	Marquette	Marquette.
Menominee County:		
Menominee Stone Crusher, Robert Rick, Prop.	2401 Broadway, Menominee	Menominee.
Lyon Bros. & Co. *Also lime.*	1106 Main St., Menominee.	Menominee.
Monroe County:		
B. E. Bullock	Samaria	Dundee.
Shore Line Stone Co.	Monroe	Frenchtown.
Smith Thatcher Quarry Co.	R. D., Maybee	Ida.
Chas. Augerer, Jr.	R. D., Maybee	Maybee (near Shofield).
Monroe Stone Co.	12 Washington St., Monroe	Monroe.
S. J. Morris	201 Laplaisance St., Monroe	Monroe.
Detroit, Monroe & Toledo Short Line & Electric R. R.	Newport	Newport.
R. H. Nogar	Samaria	Samaria.
Morris Cummins	R. D. No. 1, Samaria	Temperance.
Oakland County:		
The Henry Merdian Co.	616 Moffat Bldg., Detroit.	Clarkston.
Presque Isle County:		
Michigan Limestone & Chem. Co.	55 Liberty St., New York, N. Y.	Calcite.
Onaway Limestone Co.	Onaway	Onaway.
Schoolcraft County:		
The White Marble Lime Co.	Manistique	Blaney.
The White Marble Lime Co. *Also lime.*	Manistique	Manistique.
The White Marble Lime Co. *Also lime.*	Manistique	Marblehead.
Wayne County:		
Church Quarry Co. *Also lime.*	Sibley	Trenton & Sibley.
Dunbar Stone Co.	Detroit	Mouth of Detroit River (Quarry for Gov't work.) Stone is dredged.
Charlevoix Cement Co.	Charlevoix	Charlevoix.

MARBLE PRODUCERS, 1911.

Operators.	Office.	Quarry.
Marquette County:		
Michigan Marble Co	Detroit	Ishpeming.

SANDSTONE PRODUCERS, 1911.

Operators.	Office.	Quarry.
Eaton County:		
J. W. Willis	Grand Ledge	Grand Ledge.
Houghton County:		
The Portage Entry Quarries Co	206 So. La Salle St., Chicago, Ill	Jacobsville.
Portage Entry Redstone Co., Ltd.	Jacobsville	Jacobsville.
Huron County:		
John Holland	207-8 The Arcade, Cleveland, Ohio	Caseville.
Cleveland Stone Co	Cleveland, Ohio	Grindstone City & Port Austin.
Wallace & Sons	Port Austin	Port Austin.
Ionia County:		
David Meginnity	68 Selden Ave., Detroit	Lyons.
Marquette County:		
Furst-Neu Co	620-218 La Salle St., Chicago, Ill	Marquette.
Otsego County:		
Francis Cain	R. D. No. 2, Riga	Ottawa Lake.

GRINDSTONE PRODUCERS, 1911.

Operators.	Office.	Quarry.
Huron County:		
Eureka Grindstone Co	Ubly	Austin.
Jno. Holland	207 The Arcade, Cleveland, Ohio	Caseville.
Cleveland Stone Co.	Cleveland, Ohio	Grindstone City.
The Wallace Co	Port Austin	Grindstone City.
Cleveland Stone Co.	Cleveland, Ohio	Port Austin.

OILSTONE, WHETSTONE & SCYTHESTONE PRODUCERS, 1911.

Operators.	Office.	Quarry.
Huron County:		
Cleveland Stone Co.	Cleveland, Ohio	Grindstone City.
Cleveland Stone Co.	Cleveland, Ohio	Port Austin.
The Wallace Co	Port Austin.	Port Austin.

TRAP ROCK PRODUCERS, 1911.

Operators.	Office.	Quarry.
Marquette County:		
Lipsett & Sinclair	Marquette	Marquette.
Marquette Stone Co	Marquette	Marquette.
Powell & Mitchell	Marquette	Marquette.

QUARTZ PRODUCERS, 1911.

Name.	Office.	Mine.
Michigan Quartz Silica Co	Ishpeming	Ishpeming.

GRAPHITE PRODUCERS, 1911.

Name.	Office.	Mine.
Northern Graphite Works, Jan. 1911	L'Anse	L'Anse.
Detroit Graphite Co	10 12th St., Detroit	L'Anse.

BRICK & TILE MANUFACTURERS, 1911.

Operators.	Office.	Works.
Alger County:		
Nathaniel Lobb	Munising	Hallston.
Shaw Brick Works, Geo. W. Shaw, Prop	Marquette	Shaw.
Allegan County:		
Allegan Brick Works, Fidus E. Fish & Son, Props	Allegan	Allegan.
L. Y. Cady	289 Thomas St., Allegan	Allegan.
Zeeland Brick Co	Zeeland	Hamilton.
Alpena County:		
Richard Collins	151 Water St., Alpena	Alpena.
Michigan Enameled Brick & Tile Co	Alpena	Alpena.
Arenac County:		
Michigan Paving Brick Co	Saginaw	Omer.
M. K. Perlberg	Standish	Standish.
Cook Brick & Tile Co	Harrisville	Twining.
Barry County:		
Zeeland Brick Co	Zeeland	Cloverdale.
Wm. Leonard	Delton	Delton.
Bay County:		
Michigan Vitrified Brick Co	Bay City	Bay City.
Berrien County:		
Benton Harbor Brick & Tile Co	Benton Harbor	Benton Harbor.
Branch County:		
Lorenzo D. Reynolds & Son	Quincy	Algansee.
Charlevoix County:		
Boyne City Brick Co	Boyne City	Boyne City.
Northern Brick Co., Inc	Boyne Falls	Boyne Falls.
Price Brick Co	East Jordan	East Jordan.
Chippewa County:		
Rudyard Brick Works	Rudyard	Rudyard.
Clinton County:		
C. F. Pulfrey	St. Johns	St. Johns.
Dickinson County:		
Vulcan Brick Works	Vulcan	Vulcan.
Eaton County:		
American Sewer Pipe Co	Bessemer Bldg., Pittsburg, Pa. (Akron, Ohio, Broad St.)	Grand Ledge.
Grand Ledge Clay Product Co	Grand Ledge	Grand Ledge.
Olivet Brick & Tile Co., Ltd	Olivet	Olivet.
Emmet County:		
A. J. De Arment & Son	Petoskey	Petoskey.

BRICK & TILE MANUFACTURERS, 1911—*Continued.*

Operators.	Office.	Works.
Genesee County:		
Gale Bros	Atlas	Atlas.
Thomas Oliff	Clio	Clio.
Uptegraff Bros. & Co	Davison	Davison.
Duffield Brick & Tile Works	Duffield	Duffield.
Haas & McCann	Gaines	Gaines.
Brick & Drain Tile Co	Grand Blanc	Grand Blanc.
Otter Lake Brick & Tile Co., Stewart & Kerby	Otter Lake	Otter Lake.
Frank Sharp	R. D. No. 1, Linden	South Mundy.
Gladwin County:		
Christ Korkaske	Gladwin	Gladwin.
Grand Traverse County:		
Traverse City Brick Co	Traverse City	Keystone.
Gratiot County:		
Ashley Tile Co., Wm. Fietehenbiner	Ithaca	Ashley.
David Stevenson & Sons	Ashley	Ashley.
Ithaca Brick & Tile Yards, Redman & Thomas, Props	Ithaca	Ithaca.
Batroff & Snyder	Ithaca	North Star.
C. D. Peet	North Star	North Star.
W. H. H. Smith & Son	St. Louis	St. Louis.
Riverside Brick & Tile Works, (R. E.) Duffield Bros	Sumner	Sumner.
Hillsdale County:		
Michigan Southern Brick & Tile Co., Lee Wade, et. al., January, 1912	Jackson	Jerome.
J. B. Keiser & Son	Prattville	Prattville.
Hills & Co., (Otis E.) Hills & (Roscoe) Woolan, Props	Waldron	Waldron.
Huron County:		
Wyers & O'Connell	Ubly	Ubly.
John Lecht	Warren	Elkton.
Ernst Reinhold	Sebewaing	Sebewaing.
Ingham County:		
Clippert, Spaulding & Co	Michigan Ave., Lansing	Lansing.
Ionia County:		
Albert Brown	Saranac	Saranac.
Fred H. Van der Heyden	Ionia	Ionia.
Isabella County:		
Kane Bros	Mt. Pleasant	Mt. Pleasant.
T. Thompson & Son, (W. J. Thompson)	Mt. Pleasant	Mt. Pleasant.
Jackson County:		
American Sewer Pipe Co	Bessemer Bldg., Pittsburg, Pa. or (Akron, Ohio, Broad St.)	Jackson. (No. 34)

BRICK & TILE MANUFACTURERS, 1911—*Continued.*

Operators.	Office.	Works.
Kalamazoo County:		
Zeeland Brick Co.	Zeeland	Kalamazoo.
Kent County:		
Grand Rapids Consolidated Brick & Tiling Co.	Cor. Fuller St. & Innes Ave., Grand Rapids	Grand Rapids.
Grand Rapids Brick Co., Wm. J. Clark, Sec	Cor. Michigan Ave. & Fuller Sts., Grand Rapids	Grand Rapids.
Sparta Clay Works, H. B. Fox, Prop	Sparta	Sparta.
Leelanau County:		
James W. Markham	Traverse City	Traverse City.
Lenawee County:		
Laurenson & Sanders	Addison	Addison.
Michigan Southern Brick & Tile Co., Lee Wade, et. al., Props	Jackson	Addison Junction.
Wilt & Wotring	Ogden Center	Blissfield.
Britton Pressed Brick Co.	216 E. Washington St., Ann Arbor	Britton.
Wm. T. Atkins	Deerfield	Deerfield.
B. F. Woodford & Son	Jasper	Jasper.
G. D. Ellis	Macon	Macon.
American Brick & Tile Co.	Morenci	Morenci.
Morenci Brick & Tile Works, L. V. Lee, Prop	Morenci	Morenci.
Saxton Brick & Tile Works, J. S. Saxton & Son, Props	R. D., Blissfield	Riga.
Albert A. Comfort	R. D., Tecumseh	Tecumseh.
Mackinac County:		
Northern Michigan Brick & Tile Co.	St. Ignace	Reavie.
Macomb County:		
Jacob Hartsig	Warren	Centerline.
Frank G. Hacker	Mt. Clemens	Clinton.
East Gass	Washington, R. D. No. 2.	Davis.
Mt. Clemens Brick & Tile Co.	Mt. Clemens	Mt. Clemens.
Warren Brick & Tile Works, Schulte, Hennes & Evans, Props	Warren	Warren.
Manistee County:		
Joseph Kujawske	Oakhill	Oakhill.
William H. Kline & Son	Onekama	Onekama.
Mason County:		
A. A. Keiser	105 Ludington Ave., Ludington	Ludington.
Mecosta County:		
Wm. F. Nehmer	Milton Ave., Big Rapids	Big Rapids.

BRICK & TILE MANUFACTURERS, 1911—*Continued.*

Operators.	Office.	Works.
Midland County:		
Midland Brick & Tile Co., Olmstead & Ryal, Props	Midland	Midland.
Missaukee County:		
J. A. Smith	Cadillac	McBain.
Monroe County:		
Meyers Bros	Azalia	Azalia.
Linenfelser Brick & Tile Co., Fred Linenfelser	Maybee	Maybee.
John Strong & Son	South Rockwood	So. Rockwood.
Gerhard Rehn	Strasburg	Strasburg.
Muskegon County:		
Holton Brick Co., F. J. Connoll, Pres	Muskegon	Holton.
E. M. Ruggles	Whitehall	Whitehall.
Newaygo County:		
C. Schrier	R. D., Grant	Grant.
Oakland County:		
William H. Osmun	Cor. Auburn Ave. & Sanford St., Pontiac	Pontiac.
Oceana County:		
Walkerville Brick & Tile Co., Alton J. Walker, Prop	Walkerville	Walkerville.
Ottawa County:		
Zeeland Brick Co	Zeeland	Zeeland.
Saginaw County:		
Parker-Lohmann Brick & Tile Co.	Saginaw, W. Side, R. D. No. 10	Paines.
Peter Robie	Saginaw, W. Side, R. D. No. 10	Paines.
Sperry Bros., (Chas. E. Sperry)	Paines, via Saginaw, W. Side.	Paines.
James Day	Saginaw, R. D. No. 8	Saginaw.
Thomas Day	Saginaw, R. D. No. 3	Saginaw.
Saginaw Paving Brick Co	1850 South Jefferson St., Saginaw, E. Side	Saginaw.
St. Clair County:		
Frederick A. Beard	Atkins, R. D. No. 2	Ruby.
Belknap & Phillips	Bell River Road, St. Clair	St. Clair.
Sanilac County:		
John Large	Brown City	Brown City.
Croswell Brick Co	Croswell	Croswell.
Minden City Brick & Tile Works, A. H. Jones, Prop	Minden City	Minden City.
Dawson & Bissett	Sandusky	Sandusky.

BRICK & TILE MANUFACTURERS, 1911—*Concluded.*

Operators.	Office.	Works.
Shiawassee County:		
Detroit Vitrified Brick Co.	Corunna, Box 289	Corunna.
M. L. Parker	822 South Cedar St., Owosso	Owosso.
Reliance Motor Truck Co.	Owosso	Owosso.
Tuscola County:		
Charles Hall	Cass City	Cass City.
John Thompson & Son	Tuscola	Tuscola.
Van Buren County:		
James Stewart	R. D. No. 2, Bangor	Bangor.
L. P. Walker	Hartford	Hartford.
Wayne County:		
Charles F. Frank, (lessee) Estate of Anthony Wagner, Prop.	1254 Dix Ave., Detroit	Dearborn.
Burke Bros.	2296 Michigan Ave., Detroit	Detroit.
Jacob Daniel & Bros. Brick Co.	1955 Michigan Ave., Detroit	Detroit.
John S. Haggerty	312 Hammond Bldg., Detroit	Detroit.
John C. McDonald & Son	15 McGraw Bldg., Detroit.	Springwells.
Schneider Brick Co.	605 Dix Ave., Detroit	Detroit.
Wolf & Dei	40 29th St., Detroit	Detroit.
Bunte Bros.	Flat Rock	Flat Rock.
Beardslee Bros.	Redford	Redford.
Geo. H. Clippert & Bros. Brick Co.	1960 Michigan Ave., Detroit	Springwells.
Wm. Clippert	1950 Michigan Ave., Detroit	Springwells.
Detroit Roofing Tile Co.	304 Bamlet Bldg., Springwells-Detroit	Springwells.
Combination Brick Co	1427 Majestic Bldg., Detroit	Springwells.
Michael Downey	699 Campbell Ave	Springwells? 1977 Michigan Ave., Detroit.
Lonyo Brick Co.	Michigan Ave. & Lonyo Road, Detroit	Springwells.
Lonyo Bros.	Michigan Ave., Springwells-Detroit	Springwells.
Porath Bros.	12 Peninsula Bank Bldg., Detroit	Springwells.
Sass Bros. & Steve	32 29th St., Detroit	Springwells.
Springwells Brick Co., Walker & Frank, Props.	324 Hammond, Detroit	Springwells.
F. H. Wolk Brick Co	1476 Central Ave., Detroit	Springwells.
Wexford County:		
Estate of Robt. Wilson	Cadillac	Harriette.

PRODUCERS OF SAND-LIME BRICK, 1911.

Operators.	Office.	Works.
Genesee County:		
Flint Sandstone Brick Co.	Box 191, Flint	Flint.
Houghton County:		
Lake Superior Stone Brick Co.	Calumet	Hancock.
Huron County:		
Sebewaing Sandstone Brick Co.	Sebewaing	Sebewaing.
Jackson County:		
Jackson Pressed Brick Co	1401 Francis St., Jackson	Jackson.
Kalamazoo County:		
South Michigan Brick Co.	Kalamazoo	Kalamazoo.
Kent County:		
Grande Brick Co., Wm. Joseph, Supt.	Kalamazoo Ave., Grand Rapids	Grand Rapids.
Manistee County:		
Manistee Brick Co.	Manistee	Manistee.
Menominee County:		
Menominee Brick Co.	Broadway & Saxton Ave., Menominee	Menominee.
Ottawa County:		
Holland Manistee Brick Co	Holland	Holland.
Saginaw County:		
Saginaw Sandstone Brick Co.	321 N. Hamilton St., Saginaw	Saginaw.
Wayne County:		
Michigan Pressed Brick Co	Cor. Lawton Ave. M. C. R. R., Detroit	Detroit.
Church Brick Co	Sibley	Sibley.

PRODUCERS OF POTTERY, 1911.

Operators.	Office.	Works.
Ionia County:		
Ionia Pottery Co	Ionia	Ionia.
Washtenaw County:		
Markham Pottery, Harman C. & Kenneth S. Markham, Props	562 S. 7th St., Ann Arbor	Ann Arbor.
Wayne County:		
Detroit Flowerpot Co., T. S. Balsley & Son	490 Howard St., Detroit	Detroit.
Anton Hupprich	83 Otis St., Detroit	Detroit.
Jeffery-Dewitt Co	Detroit	Detroit.
Pewabic Pottery & Tile Co., Mary Chase Perry (Miss) & H. J. Caulkins, Props	2161 Jefferson St., Detroit.	Detroit.

CLAY MINERS, 1911.

Operators.	Office.	Mine.
Allegan County:		
Allegan Brick Works	Allegan	Allegan.
Barry County:		
Wm. Leonard	Delton	Delton.
Bay County:		
Daniel H. Shawl	1308 Stanton St., Bay City	Bay City.
Calhoun County:		
George D. Baltz & Co	209 S. Kendall St., Battle Creek	Battle Creek.
Genesee County:		
New Aetna Portland Cement Co	412 Union Trust Bldg., Detroit	Fenton.
Lenawee County:		
A. A. Comfort	Tecumseh	Tecumseh.
Mackinac County:		
Northern Brick Co	St. Ignace	"Reavie."
Ontonagon County:		
Wm. F. Emmond	Rockland	Rockland.
Jeffs Land Co., Ltd., W. B. Jeffs, Prop	Rockland	Rockland.
Robinson Clay Product Co	1010 E. Market St., Akron, Ohio	Rockland.
W. P. Vogtlin	Box 36, Rockland	Rockland.
Wexford County:		
J. Z. Stanley & Son	Harriette	Harriette.
Shiawassee County:		
New Haven Coal Mining Co. Props., Noud Kean Coal Mining Co., Lessees	Owosso	Six Mile Creek.

SAND AND GRAVEL PRODUCERS, 1911.

Operators.	Office.	Mine.
Alpena County:		
Riley & Monkman	501 State St., Alpena	Alpena.
Bay County:		
R. Hayward	R. F. D. 3, Bay City	Bay City.
Berrien County:		
Benton Harbor Sand Co	Benton Harbor	Benton Harbor.
Ed. E. Squier Co	1520 Bank of Com. Bldg., St. Louis, Mo	Benton Harbor.
Kerlikowske Bros	St. Joseph	St. Joseph.
Calhoun County:		
John Adrian	323 Hamblin Ave., Battle Creek	Battle Creek.
Geo. D. Baltz	209 Kendall St., Battle Creek	Battle Creek.
Crystal Sand & Gravel Co	Battle Creek	Battle Creek.
Chippewa County:		
Hatton Bros	Sault Ste. Marie	Sault Ste. Marie.
Jas. Rye	409 Maple St., Sault Ste. Marie	Sault Ste. Marie.
Clinton County:		
Chas. Lerg	DeWitt	DeWitt Twp.
Noah Wilhelm	Bath	Bath Twp.
Delta County:		
Chicago & N. W. R. R. Co	Chicago, Ill	Escanaba.
Escanaba Stone & Gravel Co	Escanaba	Escanaba (Flat Rock).
Dickinson County:		
Chicago & N. W. R. R. Co	Chicago, Ill	Iron Mountain.
Chicago & N. W. R. R. Co	Chicago, Ill	Loretto.
Vulcan Brick Works	Vulcan	Vulcan.
Eaton County:		
Beach Mfg. Co	Charlotte	Charlotte.
Wm. Divine & Co	Grand Ledge	Grand Ledge.
C. A. Frost	Grand Ledge	Grand Ledge.
Mrs. Hattie L. Gibbs	Grand Ledge	Grand Ledge.
V. M. Kent	Grand Ledge	Grand Ledge.
Valley City Stone & Gravel Co	19 W. Broadway, Grand Rapids	Grand Ledge.
Herman Sawyer	Grand Ledge	Delta Twp.
Washington Fultz	Grand Ledge	Mulliken.
Genesee County:		
E. Bowles	Linden	Linden.
City of Linden	Linden	Linden.
Seward Fletcher	Linden	Linden.
Geo. Sansan	Linden	Linden.
Robt. Orr	Linden	Linden.
Gogebic County:		
Chicago & N. W. R. R. Co	Chicago, Ill	Blenners.

SAND AND GRAVEL PRODUCERS, 1911—*Continued.*

Operators.	Office.	Mine.
Hillsdale County:		
Lake Shore & Mich. So. R. R. Co.	Chicago, Ill.	Jonesville.
C. Nelson E. Wolcott	Hillsdale	Hillsdale.
C. J. Stevens	Hillsdale	Hillsdale.
Huron County:		
The Cleveland Stone Co.	Cleveland	Grindstone City.
The Wallace Co.	Port Austin	Port Austin.
Miss Elizabeth A. Haskell	Port Austin	Port Austin.
Ingham County:		
Lewis Breitenwischer	512 Oakland Blk., Lansing	Lansing.
Hugh Campbell	1516 6th St., Bay City	Lansing.
Est. of Peter Malcolm	Saginaw (or Mason)	Mason.
Ionia County:		
Geo. W. Crawford	R. F. D. 3, Ionia	Ionia.
E. J. Emmons	Ionia	Ionia.
John Gardner	346 Division St., Ionia	Ionia.
Henry Miller	East Main St., Ionia	Ionia.
Ionia Cement Product Co.	R. F. D. 3, Ionia	Ionia.
Jas. M. Fellows	Lake Odessa	Lake Odessa.
Iron County:		
Chicago & N. W. R. R. Co.	Chicago, Ill.	Iron River.
Jackson County:		
Wm. Blake	R. F. D. 6, Jackson	Jackson.
Wm. P. Emmons	123 Clinton St., Jackson	Jackson.
Michigan Central R. R. Co.	Detroit	Leoni.
Kalamazoo County:		
Wm. A. Balch	1425 Forbes St., Kalamazoo	Kalamazoo.
Uriel K. Balch	1317 Summit Ave., Kalamazoo	Kalamazoo.
Samuel H. Buwrma	315-317 E. Frank St., Kalamazoo	Kalamazoo.
Chas. Ferguson	612 Forest St., Kalamazoo	Kalamazoo.
I. W. Gunn	Watervliet	Williams.
M. Haas & Son	R. D. No. 10, Kalamazoo.	Kalamazoo.
G. D. B. Hall	1204 Merrill St., Kalamazoo	Kalamazoo.
Richard Hinga	Kalamazoo	Kalamazoo.
Archie Huff	109 E. Ranson St., Kalamazoo	Kalamazoo.
Jacob Klepper	1711 N. West St., Kalamazoo	Kalamazoo.
Lane & Lay	Kalamazoo	Kalamazoo (Portage St.)
Peter Molhark	Kalamazoo	Kalamazoo.
Jacob Newhouse	210 Maple St., Kalamazoo.	Kalamazoo.
Michael Owens	833 Reed St., Kalamazoo	Kalamazoo.
Jas. T. Russell	602 Maple St., Kalamazoo	Kalamazoo.
Saml. O. Spier	Wheaton Ave., Kalamazoo	Kalamazoo.
Fred Myers	Williams	Williams.

SAND AND GRAVEL PRODUCERS, 1911—*Continued.*

Operators.	Office.	Mine.
Kent County:		
Anchor Bldg. Stone & Gravel Co..	1035 So. Div. St., Grand Rapids.	Grand Rapids.
Battjes Fuel & Bldg. Mat. Co.	Grand Rapids	Grand Rapids.
G. W. Bunker & Co	Grand Rapids	Grand Rapids.
Harrison Land Co., Ltd	Cor. Pine & 4th Sts., Grand Rapids	Grand Rapids.
Fred Jansma, Walker Ave. Gravel Co.	426 Walker Ave.	Grand Rapids.
Michigan Sand & Gravel Co	16 Hawkins Bldg., Grand Rapids	Grand Rapids.
Van Der Veer & Kloote Gravel Co..	Grand Rapids	Grand Rapids.
Livingston County:		
The Ohio & Mich. Sand & Gravel Co.	1019 Nichols Bldg., Toledo, Ohio	Chilson.
Macomb County:		
The Henderson Gravel Co.	412 So. Weadock Bldg., Saginaw	Armada.
Lake Side Ice & Coal Co	Mt. Clemens	Mt. Clemens.
H. Jacob Wacker.	Rose St., Mt. Clemens.	Mt. Clemens.
Detroit Sand & Gravel Co.	34 McGraw Bldg., Detroit.	Utica.
Manistee County:		
Consumers Coal & Ice Co.	424 River St., Manistee	Manistee.
Hubbell Sand Co.	Manistee.	Manistee.
R. M. Hoffman	Manistee.	Manistee.
Porter M. Summerfield.	290 No. Water St., Manistee	Manistee.
Marquette County:		
Chicago & N. W. R. R. Co	Chicago, Ill.	Michigamme.
Menominee County:		
Chicago & N. W. R. R. Co	Chicago, Ill.	Daggett.
Monroe County:		
Wm. Stoeckert.	Monroe.	Monroe.
National Silica Co.	Steiner (or 1009 Union Trust Bldg., Detroit)	Steiner.
Oakland County:		
The Henry Merdian Co.	616 Moffat Bldg., Detroit..	Clarkston.
Michigan Portland Cement Pav. Co.	Room 92, Griswold St., Detroit.	Clarkston
Frank B. Anderson.	Pontiac.	Pontiac.
S. Bartlett	Pontiac.	Pontiac.
W. H. Kemp	Pontiac.	Pontiac.
C. L. Rockwell.	180 Franklin Road, Pontiac.	Pontiac.
Henry C. Ward	Pontiac.	Pontiac.
Geo. Heal	669 Baker St., Detroit.	Rochester.
Michigan Builders Supply Co., I. E. Boomer	520 Forest St. E., Detroit..	Rochester.
Brown & Brown Coal Co.	Detroit.	Waterford.

SAND AND GRAVEL PRODUCERS, 1911—*Concluded.*

Operators.	Office.	Mine.
Calhoun County:		
Elbert I. Fish	15 Grove St., Battle Creek.	Battle Creek.
Roscommon County:		
Campbell Gravel Co	Roscommon	Roscommon.
Saginaw County:		
Christian Schlatterer	327 S. Water St., Saginaw.	Saginaw.
Thos. B. Cresswell	Saginaw	River bend, Saginaw.
C. B. Moiles	336 Howard St., Saginaw.	Saginaw River.
St. Clair County:		
C. A. Cadwell	Windsor, Ont	Port Huron.
E. Jaques & Sons	Foot of First St., Duluth, Minn.	Port Huron.
Knisley & Co	333 River St., Port Huron	Port Huron.
Marine Contracting Co	211 Quay St., Port Huron	Port Huron.
Reliance Sand & Gravel Co	Port Huron	Port Huron.
Sanilac County:		
Dawson & Son	Sandusky	Sandusky.
Washtenaw County:		
S. A. Elsifor	117 No. 1st St., Ann Arbor	Ann Arbor.
Concrete Supply Co	Toledo, Ohio	Geddes.
Lake Shore & Mich. R. R	Cleveland, Ohio	Manchester.
Wayne County:		
The C. H. Little Co	320 Penobscot Bldg., Detroit	Detroit.
John M. McKershey	Room 2, Anchor Line Bldg., Detroit	Detroit.
American Silica Co	Rockwood	Rockwood.
C. H. Little & Co	Detroit, Dec., 1911	Algonac.
H. Houghten	806 Hammond Bldg., Detroit	Utica.
COUNTY. (?)		
Chicago, Milwaukee & St. Paul R. R	Chicago, Ill	....

UNVERIFIED NAMES OF SAND AND GRAVEL PRODUCERS, 1911.

Name.	Address.
Herman Eckert	Grand Ledge.
Chas. Garlock	Grand Ledge.
Jas. Gibbs	Grand Ledge.
Paul Livingback, (or Irvingback)	Manistee.
Albert Myers	R. D. 6, Jackson.
Wm. Sipley	Bath.
The Superior Sand & Gravel Co	Detroit, (or Utica).
Williams Coal Co	Lansing.
Nelson E. Wolcott	Hillsdale.

PRODUCERS OF MINERAL WATERS, 1911.

Spring.	Company.	Address.
Arctic	Arctic Spring Water Co., Cornelius Van Rossum	250 N. Ottawa St., Grand Rapids.
Bromo-Hygeia Well	Bromo-Hygeia Mineral Water Co., Ltd	Coldwater.
Cooper Farm	Walker Gordon	Birmingham.
Crystal	Crystal Springs Water, Fuel & Northern Ice Co	97 Ottawa St., Grand Rapids.
Eastman Springs	Eastman Springs Co., W. H. Woodruff	Benton Harbor.
Harrison Springs	Geo. A. Ford	380 W. Bridge St., Grand Rapids.
Lake Superior Mineral Springs	Polaris Water Co	Marquette.
Panthurst Spring	Panthurst Spring Water Co	Grand Rapids.
Lansingwald	Panthurst Spring Water Co	Grand Rapids.
Maple Leaf Springs	Jno. H. Charbeneau	Mt. Clemens.
Midland Mineral	W. L. Stearne	Midland.
Moorman	Ypsilanti Mineral Bath & Water Co	Ypsilanti.
No-Che-Mo	No-Che-Mo Mineral Spring Co	Reed City.
Ogemaw	J. W. Kinney	Bay City.
Osseo	C. M. DeWitt	Hillsdale.
Pagoda	Pagoda Water Co	Mt. Clemens.
Ponce-de-Leon	Ponce de Leon Co	98 S. Div. St., Grand Rapids.
Royal Oak Lithia	Royal Oak Lithia Water Co	Detroit (Royal Oak).
St. Louis Magnetic Mineral	Magnetic Spring Water Co	Saginaw, W. S.
Salutaris	Salutaris Water Co	411 Hammond Bldg., Detroit.
Sanitas	Lute H. Pike	Topinabee.
Silver Springs	Silver Springs Water Co	40 W. Leonard St., Grand Rapids.
Sprudel	P. H. Irish	Mt. Clemens.
Sterling	Jackson Bros	Crystal Falls.
Victory	Charles Shorkey	Mt. Clemens.
White Oak	Alden Bros	Battle Creek.

PETROLEUM PRODUCERS, 1911.

St. Clair County:
Michigan Developing Co. . . . . 130 Huron Ave., Port Huron.

MISCELLANEOUS STATISTICAL TABLES.

Compiled from reports of the United States Geological Survey, Division of Mineral Resources. Statistics for 1910 collected by Michigan Geological Survey and United States Geological Survey in coöperation.

VALUE OF THE PRODUCTION OF POTTERY IN MICHIGAN, 1899-1910.

Year.	Rank of state.	Firms.	Red earthenware value.	Porcelain electrical supplies value.	C. C. ware value.	Miscellaneous value.	Total value.	Per cent of total product in U. S.
1899	18	4	29,641		100		29,741	.17
1900	17	4	34,317				34,317	.17
1901	16	5	42,465			2,400	44,865	.20
1902	14	4	44,098			39,000	83,098	.41
1903	19	4	42,007			6,000	48,007	.19
1904			40,621			3,000	43,621	
1905	17	5	a		a	7,000	45,961	.16
1906	17	6	43,510			7,600	51,110	.16
1907	16	6	54,474			7,100	61,574	.20
1908	16	6	54,659			7,750	62,409	.25
1909	13	5	60,939			34,500	95,439	.31
1910	13	6	90,450	a		13,300	112,697	.33
Totals						127,650	712,839	

a Included in the total.

*55

OUTPUT OF MINERAL WATERS IN MICHIGAN, 1900-1910.

Year.	No. of springs.	Total. Quantity, gal.	Total. Value.	Medicinal Value.	Table Value.	Price per gal.
1900........	28	3,398,996	411,935	....	....	....
1901........	28	7,019,168	1,195,614	....	....	....
1902........	28	8,653,690	275,763	....	....	....
1903........	19	6,919,107	200,668	....	....	....
1904........	19	3,385,675	118,422	....	....	....
1905........	17	2,684,800	277,188	38,900	238,288	$ 10
1906........	19	902,528	73,357	....	....	....
1907........	19	1,472,679	127,133	35,091	92,042	9
1908........	24	2,004,433	88,910	5,995	82,915	4
1909........	19	2,760,604	104,454	6,099	98,355	4
1910........	17	1,454,020	69,538	100	69,438	5
....	....	40,655,700	2,942,982	86,185	581,038	....

PRODUCTION OF CLAY IN MICHIGAN FOR 1910.

Slip clay.		Brick clay.		Miscellaneous clay.		Total.	
Quantity, tons.	Value.	Quantity, tons.	Value.	Quantity, tons.	Value.	Quantity, tons.	Value.
1,363	3,889	60	105	1	400	1,424	4,394

***VALUE OF THE PRODUCTION OF SANDSTONE IN MICHIGAN, 1899-1910.**

Year.	Rough building value.	Dressed building value.	Curbing value.	Flagging value.	Rubble value.	Riprap value.	Crushed stone.		Other value.	Total value.
							Road making value.	Concrete value.		
1899	102,447	51,682	109	a	....	....	....	....	23,800	178,038
1900	73,850	58,800	....	....	....	....	....	....	....	132,650
1901	128,909	....	....	....	26,519	b	....	....	19,000	174,428
1902	136,280	23,600	....	....	27,393	800	....	....	....	188,073
1903	89,931	10,365	....	....	15,554	....	2,050	3,450	....	121,350
1904	47,593	14,818	....	....	10,657	....	1,400	400	....	74,868
1905	64,056	36,035	....	....	10,332	....	....	....	12,700	123,123
1906	35,272	18,950	....	....	10,403	770	....	....	....	65,395
1907	33,561	10,918	....	528	7,900	96	....	....	....	53,003
1908	15,100	18,813	....	....	5,190	....	....	....	....	39,103
1909	12,985	16,805	....	....	6,294	....	....	....	....	36,084
1910	13,312	15,416	....	....	2,505	....	....	....	....	31,233
Totals	753,296	276,202	109	....	122,747	....	3,450	3,850	55,500	1,217,348

a Included under curbing.
b Included under rubble.
* Exclusive of sandstone made into grindstones and whetstones.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1910.

Year.	Lime burned.		Average price per ton.	No. of plants operating.	Rank of state.
	Quantity, tons.	Value.			
1904	63,601	256,955	$4 04	....	....
1905	48,089	192,844	4 01	....	....
1906	68,133	281,465	4 13	13	....
1907	65,822	276,534	4 20	12	....
1908	68,050	282,023	4 14	10	15
1909	83,108	354,135	4 26	12	13
1910	72,345	303,377	4 19	10	14
Total	469,148	1,947,333	....	....	....

VALUE OF THE PRODUCTION OF LIMESTONE IN MICHIGAN, 1899-1910.

Year.	Rough building value.	Dressed building value.	Paving value.	Curbing value.	Flagging value.	Rubble value.	Riprap value.	Crushed stone.			Flux value.	Sugar factories value.	Sold to lime burners value.	Other value.	Total value.
								Road making value.	Railroad ballast value.	Concrete value.					
1899	30,299	a	62,815	....	....	....	1,111	....	....	....	27,512	....	157,657	2,375	281,769
1900	32,362	a	105,266	....	....	....	799	....	....	....	3,200	....	65,000	124,220	330,847
1901	47,785	a	....	b	380	5,098	c	31,605	18,200	75,643	13,488	....	136,173	101,399	429,771
1902	58,707	a	....	489	200	3,101	5,740	56,261	40,810	49,430	32,246	....	98,000	68,164	413,148
1903	36,528	a	49,000	250	5,150	710	800	61,342	35,340	48,504	15,502	....	132,600	4,747	390,473
1904	32,941	805	37,665	....	....	2,800	2,405	58,655	57,100	60,745	62,586	....	180,683	5,323	501,708
1905	17,071	....	....	160	....	744	1,568	112,113	43,649	107,396	109,883	....	9,380	142,790	544,754
1906	9,368	641	90,723	75	....	4,654	1,204	78,437	103,442	61,852	81,517	224,356	....	....	656,269
1907	15,120	100	56,500	....	....	1,433	1,234	131,708	46,516	97,762	109,429	22,234	....	278,297	760,333
1908	7,276	....	10,825	300	100	15,907	1,574	182,510	33,900	73,200	56,841	32,594	....	253,990	669,017
1909	4,450	7,445	....	....	....	1,572	3,615	132,902	42,445	112,829	91,915	25,845	....	327,571	750,589
1910	3,552	....	35,500	....	....	2,205	908	110,184	42,358	178,318	100,149	69,647	....	299,305	842,126
Total	295,459	....	448,294	....	5,730	38,224	20,958	955,717	463,760	865,679	704,268	374,676	779,493	1,608,181	6,570,804

a Included under rough building.
b Included under flagging.
c Included under rubble.

PRODUCTION OF VALUE OF SAND AND GRAVEL IN MICHIGAN, 1904-1910.

Year.	Glass sand.		Molding sand.		Building sand.		Fire sand.		Engine sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value
1903.....	....	....	....	....	....	....	....	....	....	.....
1904.....	....	....	167,147	76,299	69,656	30,898	....	....	....	.....
1905.....	....	....	19,382	13,247	263,315	148,065	5,000	2,500	....	.....
1906.....	600	3,000	61,387	26,108	403,199	127,937	....	....	4,000	400
1907.....	4,300	8,600	54,172	24,190	451,646	157,150	6,000	3,000	1,534	153
1908.....	17,000	34,000	4,584	2,892	474,238	228,395	....	....	1,991	319
1909.....	65,000	79,000	53,226	20,756	1,090,419	327,247	4,000	2,000	12,415	1,493
1910.....	16,212	25,675	93,812	24,004	1,151,588	334,336	5,000	3,000	22,270	2,172
Totals..	103,112	150,275	453,710	187,496	3,904,061	1,354,028	20,000	10,500	42,210	4,537

PRODUCTION OF VALUE OF SAND AND GRAVEL IN MICHIGAN, 1904-1910.

Year.	Furnace sand.		Other sand.		Gravel.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1903.....	....	....	....	....	....	....	....	....
1904.....	....	....	....	....	....	....	236,803	107,197
1905.....	....	....	50,187	14,476	76,625	32,321	414,509	210,609
1906.....	5,000	2,500	51,005	12,140	72,598	25,614	597,789	197,699
1907.....	3,858	3,133	173,724	12,187	329,407	81,182	1,024,641	289,595
1908.....	3,329	3,828	29,187	6,850	312,262	94,081	842,591	370,365
1909.....	3,183	3,660	295,612	50,953	695,902	200,523	2,219,757	685,632
1910.....	3,185	4,924	372,880	57,385	1,197,791	364,841	2,862,738	816,337
Totals..	18,555	18,045	972,595	153,991	2,684,585	798,562	8,198,828	2,677,434

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN, 1904-1910.

Year.	Number of operating plants.	Common brick.		Front brick.		Fancy brick.		Total value.
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
1904	10	9,886,000	64,034	580,000	5,234	19,000*	497	69,765
1905	12	24,841,000	155,883	1,577,000	12,893	24,000*	526	169,302
1906	11	27,281,000	162,879	1,796,000	12,022	700*	20	174,921
1907	13	25,488,000	158,606	2,000,000*	14,234	....	....	172,840
1908	10	21,997,000	131,827	900,000*	6,982	....	....	138,809
1909	11	34,217,000	207,082	1,600,000*	11,144	....	....	218,226
1910	10	37,648,337	218,627	3,255,890	22,022	....	....	240,649
	Grand total..	181,358,337	1,098,938	11,708,890	84,531	43,700	1,043	1,184,512

*Estimated.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1910.

Year.	Common brick.		Average price per M.	Front brick.		Average price per M.	Vitrified brick.		Average price per M.	Fancy or ornamental brick.	Fire brick.		Average price per M.
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.			Quantity.	Value.	
1899...	200,144,000	933,176	$4 66	4,290,000	58,920	$13 73	a	a	....	....	....	....	....
1900...	180,892,000	863,250	4 77	8,421,000	48,411	5 75	a	a	$12 42	....	....	....	....
1901...	215,836,000	1,095,254	5 07	9,476,000	64,031	6 76	a	a	12 30	....	....	....	....
1902...	237,254,000	1,331,752	5 61	5,684,000	42,792	7 53	a	a	12 26	....	....	....	....
1903...	215,791,000	1,251,572	5 80	2,225,000	19,000	8 54	a	a	13 27	....	....	....	....
1904...	205,196,000	1,116,714	5 44	1,080,000	7,500	6 94	a	a	13 28	....	....	....	$13 00
1905...	211,558,000	1,152,505	5 45	693,000	5,995	8 65	6,112,000	81,706	13 37	....	....	....	19 37
1906...	206,583,000	1,178,202	5 70	1,474,000	14,162	9 61	6,229,000	81,814	13 13	....	....	....	10 05
1907...	200,817,000	1,181,015	5 88	3,956,000	32,116	8 12	7,911,000	94,601	11 96	....	....	....	12 00
1908...	181,049,000	994,525	5 49	1,896,000	19,496	10 28	6,165,000	76,630	12 43	....	....	....	....
1909...	219,820,000	1,250,787	5 69	2,379,000	18,654	7 84	10,473,000	129,283	12 34	....	....	....	....
1910...	232,551,000	1,363,316	5 86	2,209,000	27,533	12 46	9,080,000	116,446	12 82	....	....	....	....
Totals.	2,507,491,000	13,712,068	....	43,783,000	358,610	....	45,970,000	580,480(b)	....	....	....	....	....

a Concealed, less than three producers. b Totals for five years only.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1910.

Year.	Stove linings.	Drain tile.		Sewer pipe.	Fire-proofing.	Tile (not drain).	Miscellaneous.	Hollow building tile or blocks.	Per cent of total product in U. S.	Rank of state.	No. of firms operating.	Total value.
	Value.	Quantity.	Value.	Value.	Value.	Value.	Value.					
1899	....	....	140,171	50,300	5,900	....	22,709	....	1.68	13	196	1,254,256
1900	....	....	114,747	57,916	2,350	....	406	....	1.50	17	189	1,147,378
1901	....	....	98,972	a	1,880	....	637	....	1.71	14	180	1,497,169
1902	....	....	96,645	a	3,290	....	....	....	1.69	13	182	1,660,942
1903	....	....	129,028	a	....	....	....	19,138	1.58	14	178	1,662,414
1904	....	....	208,088	a	....	....	....	8,080	1.58	14	168	1,670,892
1905	....	....	205,445	a	a	....	....	3,585	1.41	16	154	1,719,746
1906	....	....	314,098	a	....	....	....	4,290	1.38	16	142	1,793,367
1907	....	....	289,868	a	....	....	1,500	6,386	1.39	17	136	1,786,190
1908	....	....	327,630	a	4,100	....	40,100	....	1.54	16	132	1,666,381
1909	....	....	364,006	a	a	....	66,128	....	1.44	16	122	1,947,059
1910	....	....	348,205	a	....	....	a	....	1.53	15	118	2,083,525
Totals	....	....	2,636,903	....	....	....	....	41,479	....	....	....	19,889,319

a Concealed, less than three producers. b Totals for five years only.

SUMMARY OF MINERAL PRODUCTS OF MICHIGAN FOR 1910.

Product.	Quantity.	Value.
Iron ore, long tons	13,303,906	$41,393,585
Copper, pounds	221,462,984	28,125,799
Pig iron (c), long tons	1,250,103	19,464,104
Cement, barrels	3,687,719	3,378,940
Coal, short tons	1,534,967	2,930,771
Salt, barrels	9,452,022	2,231,262
Brick and tile	....	2,083,525
Coke, short tons	392,516	1,427,963
Limestone	....	842,126
Sand and gravel, short tons	2,862,738	816,337
Gypsum and gypsum products, short tons	357,174	668,201
Lime burned, short tons	72,345	303,377
Sand lime brick	....	240,649
Silver, fine ounces (Troy)	262,200	141,600
Grindstones (d)	a	a
Pottery	....	112,697
Mineral paints	a	a
Mineral waters, gallons sold	1,454,020	69,538
Traprock	a	a
Sandstone	....	31,233
Glass sand, short tons	....	b
Graphite	....	a
Whetstones and scythe stones	....	a
Quartz	....	a
Clay	....	4,394
Petroleum (d)	....	a
Gems and precious stones	....	2,500
Miscellaneous	....	278,442
Grand total	....	$104,547,043

a Included under miscellaneous.
b Included with sand and gravel.
c Calculated from the total production and the average price per ton of pig iron in the United States for 1910. The value obtained is considerably too low as Michigan pig iron is chiefly charcoal pig which commands a higher price than coke pig iron.
d Estimated.

APPENDIX

REPORT OF THE PRODUCTION OF MINERALS AND MINERAL PRODUCTS IN MICHIGAN FOR 1911

These figures were received and compiled after transmission of manuscript of this volume to the press.

PRODUCTION OF IRON ORE IN 1911.

GOGEBIC RANGE.

Mines.	*Shipments, long tons.	‡Sales, long tons.	Value at mines.	Stocks on hand Dec. 31, long tons.	Average of iron dried at 212° F.
Anvil	310	310	$208	41,036	59.21
Ashland	151,478	151,478	436,256	64,138	58.01
Asteroid	20,570	20,570	66,030	28,580	59.31
Aurora (Includes Vaughn)	....	181,859	636,748	107,488	61.62
Brotherton	65,015	65,015	257,485	59,928	57.62
Castile	23,598	23,598	56,635	47,491	59.10
Chicago	....	....	....	32,610	....
Colby	41,630	41,630	120,727	3,642	59.00
Davis	....	....	....	1,140	....
Eureka (Wisconsin)	98,609	98,609	274,233	22,797	60.68
Geneva	....	....	....	4,555	....
Ironton (Includes Ada)	63,359	63,402	158,505	37,925	59.00
Mikado	....	....	....	15,358	49.98
Newport	560,760	555,853	1,821,416	251,981	61.47
Norrie Group ... b	883,910	a 702,051	a 2,332,178	a 543,571	61.38
Palms	....	....	....	14,814	62.66
Puritan (Ruby)	....	....	....	87,232	....
Royal	....	....	....	1,238	....
Sunday Lake	56,096	56,096	213,400	41,558	56.85
Tilden	138,387	138,387	415,226	43,337	60.09
Yale (West Colby)	154,944	155,487	416,705	6,168	59.53
Total	2,258,666	2,254,345	$7,205,752	1,456,587	....

MARQUETTE RANGE.

Mines.	*Shipments, long tons.	‡Sales, long tons.	Value at mines.	Stocks on hand Dec. 31, long tons.	Average of iron dried at 212° F.
American-Boston	194,979	174,723	$621,531	9,028	57.70
Austin	105,078	105,078	h	104,545	61.18
Barron	....	60,731	e 208,915	32,336	59.85
Beaufort	....	....	....	1,200	47.00
Breitung Hematite No. 1	} 139,582	64,643	e 222,372	20,770	60.02
Breitung Hematite No. 2		74,933	e 206,066	4,611	56.43
Cambria (Includes Hartford)	90,316	67,869	195,463	105,981	51.276
Champion	....	....	....	143,760	....
Cleveland Cliffs Group ... c	344,950	....	....	....	....
Cleveland Lake (Under Cleveland Cliffs Group)	....	166,850	h	231,823	58.57
Cliff Shaft (Under Cleveland Cliffs Group)	....	86,766	h	199,914	59.74
Empire	17,117	17,117	14,549	28,447	39.91
Franklin	....	1,860	e 6,398	1,455	59.85
Gwinn	197	197	232	307	49.05
Hartford (Under Cambria)	....	....	....	....	....
Imperial	84,843	84,843	h	96,730	51.80
Jackson	52,615	52,615	h	....	39.78
Lake Angeline	188,645	167,258	518,500	24,731	66.10
Lake Superior	174,959	174,874	523,173	281,662	56.59
Lillie	844	23,863	68,725	62,937	51.233
Lloyd	28,033	28,003	h	43,937	54.04
Lucy (McOmber)	16,677	16,677	h	71,675	45.40
Maas	24,927	24,927	h	2,300	58.00
Mary Charlotte	343,434	343,434	e 944,444	20,106	56.43
Milwaukee-Davis	7,781	7,781	e 21,398	2,171	56.43

*From Iron Trade Review, March 7, 1912.
‡In cooperation with U. S. Geol. Surv. Dept. of Mineral Resources.
a Exclusive of Aurora.
b Includes Norrie, E. Norrie, N. Norrie, Pabst, Aurora.
c Includes Salisbury, Michigamme, Cliff Shaft (Iron Cliffs), Foster, Barnum, Cleveland Lake.
e Estimated.
h Included in totals.

PRODUCTION OF IRON ORE IN 1911.

MARQUETTE RANGE.—*Continued.*

Mines.	*Shipments, long tons.	‡Sales, long tons.	Value at mines.	Stocks on hand Dec. 31, long tons.	Average of iron dried at 212° F.
Mitchell		21,387	$57,750	3,499	63.95
Moore				15,910	
Moro				191,417	56.66
Negaunee	140,406	140,406	*h*	263,565	59.12
Ohio (Beaufort)	2,684	2,684	6,441	21,662	47.40
Princeton	27,962	27,962	*h*	300,356	60.62
Queen Group *f*	297,675	297,675	821,881	160,831	58.73
Republic	113,012	120,089	356,911	41,978	65.12
Richmond	47,586	47,294	34,744		40.92
Rolling Mill	96,585	96,585	154,536	18,326	59.21
Salisbury (Under Cleveland Cliffs Group)		91,334	*h*	128,631	54.23
Star West	4,466	4,466	6,699		
Stegmiller	45,122	45,122	127,154	15,146	60.42
Stephenson	128,839	128,839	*h*	185,792	60.11
Volunteer		51,864	178,282	45,011	60.00
Total	2,719,284	2,820,749	$7,881,283	2,882,350	

MENOMINEE RANGE.

Mines.	*Shipments, long tons.	‡Sales, long tons.	Value at mines.	Stocks on hand Dec. 31, long tons.	Average of iron dried at 212° F.
Antoine (Clifford-Traders)					
Appleton (Eleanor)					
Aragon	201,187	201,269	$475,699	202,000	53.34
Armenia	51,862	51,862	129,655	86,843	57.00
Baker	3,290	3,289	8,223	40,431	57.00
Baltic (Includes Fogarty)	*d* 66,502	134,118	352,744		50.31
Bates				240	54.60
Berkshire	22,273	22,273	49,001	32,850	51.83
Bristol		322,647	589,083	25,730	55.69
Calumet				57,255	
Caspian	165,660	165,660	462,075	25,390	50.88
Chapin	357,598	357,598	980,154	179,469	55.50
Chatham	58,056	58,056	159,073	13,792	56.61
Chicagon	108,947	108,947	239,683		
Clifford-Traders (Antoine)	74,138	74,138	59,310		40.00
Crystal Falls	710	710	*e* 1,775	6,946	
Cuff				10,441	
Cundy				3,253	
Cyclops (Under Penn Group)					60.71
Davidson No. 1 and No. 2	45,434	45,434	100,405	9,121	{ 55.65 58.41
Dober (Under Riverton)					
Dunn	232,093	232,092	464,184	71,788	56.00
Eleanor (Appleton)					
Fairbanks				1,691	
Fogarty (Under Baltic)	67,616				
Genesee (Ethel)(Under Tobin)					
Gibson	57,100	57,099	68,576		45.42
Great Western (Includes Lincoln)	84,339	84,338	164,459	230,998	
Groveland	31,907				
Harpes (Under Penn Group)					58.82
Hemlock	107,752	105,320	292,804	33,913	50.72
Hiawatha	116,736	116,736	256,819	73,906	
Hollister	5,021	4,971	*e* 5,319	30,085	52.45
Iron River (Under Riverton)					48.39
Isabella (Under Riverton)				8,100	

* From Iron Trade Review, March 7, 1912.
‡ In co-operation with U.-S. Geol. Surv. Dept. of Mineral Resources.
d Exclusive of Fogarty.
e Estimated.
f Buffalo, Prince of Wales, So. Buffalo.
h Included in totals.

PRODUCTION OF IRON ORE IN 1911.

MENOMINEE RANGE.—*Concluded.*

Mines.	*Shipments, long tons.	‡Sales, long tons.	Value at mines.	Stocks on hand Dec. 31, long tons.	Average of iron dried at 212° F.
Jupiter (Under Penn Group)					40.37
James (Osana)	50,439	49,689	$99,378	34,912	§ 52.28
Kimball				13,061	
Kowinsky (Wauseca)		749	1,498		§ 52.00±
Lincoln (Under Gt. Western)					
Loretto	18,655	18,655	31,113	105,409	53.00
Mansfield	54,646	54,646	145,796	68,191	56.92
Mars (Under Penn Group)					43.56
McDonald	5,240	5,240	2,620		54.00
Michigan				69,708	
Millie	17,040	18,567	58,412		
Munro	9,303	9,302	10,232		
Nanaimo				20,000	
Penn Group †	377,026	431,200	1,071,199	141,426	
Pewabic (Includes Walpole)	352,603	352,297	547,000		{ 38.00 56.00
Quinnesec				5,814	
Riverton (Includes Dober, Iron River, etc)	198,589	200,142	567,803	43,800	56.08
Tobin (Includes Genesee)	308,457	333,798	834,495	29,923	57.00
Tully	8,324	8,324	20,810	8,229	57.00
Vivian	5,971	5,971	7,454	26,393	37.15
Vulcan (Under Penn Group)					57.98
Walpole (Under Pewabic)					
Wickwire	1,919	1,900	4,370	6,500	56.50
Youngs	89,451	89,130	200,000	2,527	48.39
Zimmerman	112,029	110,084	253,954	9,953	
Total	3,467,913	3,836,251	$8,715,175	1,730,088	
Grand total	8,445,863	8,911,345	$23,802,210	6,069,025	

* From Iron Trade Review, March 7, 1912.
‡ In co-operation with U. S. Geol. Surv. Dept. of Mineral Resources.
† Buffalo, Prince of Wales, So. Buffalo.
§ Natural.

COAL PRODUCTION OF MICHIGAN IN

Colliery.	Operator.	Office.
Bay County:		
Beaver	Beaver Coal Co	Bay City
Monitor	Handy Bros. Mining Co	Bay City
Michigan	Michigan Coal and Mining Co	Bay City
No. 5	Robt. Gage Coal Co	
No. 6	Robt. Gage Coal Co	Bay City
No. 7	Robt. Gage Coal Co	
United City	United City Coal Mining Co	Bay City
What Cheer	What Cheer Coal Mining Co	Bay City
Central	Central Coal Mining Co	Saginaw
Wolverine No. 2	Wolverine Coal Co	Saginaw
Wolverine No. 3	Wolverine Coal Co	Saginaw
County total		
Clinton County:		
Eagle	F. L. Reed	Grand Ledge
County total		
Eaton County:		
Schumaker	A. B. Schumaker	Grand Ledge
	American Sewer Pipe Co	Akron, Ohio
	Grand Ledge Clay Products Co	Grand Ledge
	Grand Ledge Coal Co	
County total		
Genesee County:		
	Burton Coal Mining Co	Flint
Genesee	Genesee Coal Mining Co	Flint
County total		
Ingham County:		
	T. W. Jenkins	Williamston
County total		
Saginaw County:		
No. 1	Robert Gage Coal Co	
No. 2	Robert Gage Coal Co	Bay City
No. 3	Robert Gage Coal Co	
No. 4	Robert Gage Coal Co	
Barnard	Barnard Coal Co	Saginaw
Buena Vista	Buena Vista Coal Co	Saginaw
Caledonia No. 2	Caledonia Coal Co., Ltd	Saginaw
	Consumers' Coal Co	Saginaw
Northern	Northern Coal Co	Saginaw
Pere Marquette No. 3	Pere Marquette Coal Co	Saginaw
Riverside	Riverside Coal Co	Saginaw
Saginaw	Saginaw Coal Co	Saginaw
Shiawassee	Shiawassee Coal Co	Saginaw
Uncle Henry	Uncle Henry Coal Co	Saginaw
Swan Creek	Bliss Coal Co	Swan Creek
	Carbon Coal Co	Saginaw
County total		
Shiawassee County:		
New Haven	New Haven Coal Mining Co	Calumet
	Noud Kean Coal Mining Co	Owosso
Peak	Detroit Vitrified Brick Co	Corunna
County total		
Tuscola County:		
Akron	Handy Bros. Mining Co	Bay City
County total		
	Small Mines	
State total		

1911, BY COUNTIES AND MINES.

Distribution of total products.				Total value.	Average price per ton.	Average number of days active.	Average number of employes.
Loaded at mines for shipment.	Sold to local trade and employes.	Used at mines for steam and heat.	Total quantity.				
11,303	....	600	11,903	$21,078	....	211	10
52,527	629	4,358	57,514	112,993	2.03	190	125
....	....	....	....	....	....	....	....
245,430	1,770	19,440	266,640	464,736	1.88	231	546
98,437	5,000	8,500	111,937	226,091	2.18	230	190
8,425	....	....	8,425	17,938	....	125	60
58,336	....	....	58,336	116,962	....	150	255
202,329	....	....	202,329	360,686	....	235	400
676,787	7,399	32,898	717,084	$1,320,484	1.84	211	1,586
....	600	....	600	$1,800	3.00	150	5
....	600	....	600	$1,800	3.00	150	5
....	....	....	....	....	....	....	....
....	1,000	....	1,000	$2,500	2.50	....	....
....	....	....	....	....	....	....	....
....	1,000	....	1,000	$2,500	2.50	....	....
8,911	....	....	8,911	$20,050	2.25	282	75
8,911	....	....	8,911	$20,050	2.25	282	75
....	1,800	180	1,980	$4,860	2.70	247	12
....	1,800	180	1,980	$4,860	2.70	247	12
163,620	1,180	12,960	177,760	$309,824	1.88	231	364
....	....	....	....	....	....	....	....
....	16,833	800	17,633	29,271	1.66	225	40
....	34,393	1,000	35,393	68,215	1.98	252	72
71,311	....	....	71,311	140,904	....	225	170
72,397	....	....	72,397	144,958	....	200	210
78,762	....	....	78,762	157,073	....	250	120
120,670	....	....	120,670	236,596	....	250	260
11,050	....	....	11,050	23,153	....	125	70
77,853	....	5,125	82,978	157,658	....	219	145
....	....	....	....	....	....	....	....
595,663	52,406	19,885	667,954	$1,267,652	1.66	225	1.451
547	94	....	641	$2,102	3.28	20	} 40
8,588	1,516	....	10,104	33,142	3.28	220	}
....	2,175	....	2,175	7,134	3.28	240	4
9,135	3,785	....	12,920	$42,378	3.28	240	44
56,648	2,798	5,840	65,286	$130,855	2.12	187	150
56,648	2,798	5,840	65,286	$130,855	2.12	187	150
....	339	....	339	882	....	....	....
1,347,144	70,127	58,803	1,476,074	$2,791,461	1.78	218	3323

CEMENT.

	Quantity. (Barrels.)	Value.
Portland cement	3,686,716	$3,024,676 00
Stock on hand December 31st	506,756	....
Daily capacity of plants operating	22,400	....

Plants operating, 8.
Plants idle or gone out of business during year, 2.

SALT.

	Quantity.		Value.
	Barrels.	Tons.	
Table and dairy	817,486	114,448	$742,702
Common fine	2,362,075	330,691	698,203
Common coarse	2,070,745	289,904	745,720
Packers	105,401	14,756	45,421
Other (including rock salt)	576,595	80,723	181,865
Brine	4,387,772	614,288	219,244
Total	10,320,074	1,444,810	$2,633,155

Bromine, calcium chloride, etc., $129,632.
Plants operating, 35.
Plants idle or gone out of business during the year, 2.

BRICK AND TILE.

	Quantity.	Value.
Common brick	198,251,589	$1,053,822
Vetrified paving brick and block	5,196,700	72,736
Front brick	2,498,275	31,572
Drain tile	....	346,848
Sewer pipe	....	109,175
Fireproofing	....	50,125
Stove lining	....	3,971
Fire brick	66,300	1,193
Total	....	$1,633,401

PRODUCTION OF LIMESTONE.

	Quantity. (Tons.)	Value.
Building purposes (rough)	6,941	$4,926
Building purposes (sawed or cut)	1,600	1,550
Paving	....	....
Curbing	....	....
Rubble	220	165
Riprap	....	....
Crushed stone for road making	228,865	99,628
Railroad ballast	80,073	34,998
Concrete	197,265	85,727
Blast furnace	366,515	172,596
Alkali works	724,529	414,434
Sugar factories	74,451	62,241
Glass factories	622	964
Paper mills	11,130	9,758
Agricultural purposes	3,554	1,677
Other purposes	139,442	63,697
Total	1,835,197	$952,471

PRODUCTION OF GYPSUM AND GYPSUM PRODUCTS.

	Quantity. (Tons.)	Value.
Quantity mined	347,296	....
Quantity sold crude—		
To Portland cement plants	63,489	$69,497
As land plaster	15,548	15,706
For other purposes	13	52
Total sold crude	79,050	$85,255
Quantity sold calcined—		
As hard wall plaster	146,920	$381,362
As Plaster Paris, etc.	47,989	88,168
As dental plaster	20	110
To plate glass works	11,370	19,031
Total sold calcined	206,299	$488,671
Total value	....	$573,926

Number of mines and quarries, 8.
Total number of kettles in mills, 29.
Total daily capacity (est.), 2400.
Material used, Rock gypsum.
Fuel, Coal.

PRODUCTION OF SAND AND GRAVEL.

	Quantity. (Tons.)	Value.
Glass sand	145,107	$70,331
Molding sand	70,302	15,914
Building sand	850,595	237,625
Stone sand	675	125
Fire sand	1,200	3,000
Engine sand	18,750	....
Furnace sand	4,269	4,800
Other sand	18,853	3,281
Concrete	161,781	29,887
Gravel	560,069	158,876
Total	1,831,601	$523,839

SAND LIME BRICK.

	Quantity.	Value.
Common brick	32,889,000	$192,224 00
Front brick	2,726,000	17,777 00
Total	35,615,000	$210,001 00

Plants operating, 10.
Plants idle or gone out of business during year, 2.

PRODUCTION OF LIME.

	Quantity. (Bbls.)	Value.
Lime sold (For building and whitewashing)	166,362	$69,139
Alkali works	....	....
Chemical works	170,441	80,167
Paper mills	5,300	2,239
Sugar factories	5,000	1,500
Tanneries	7,000	2,951
Agricultural purposes (fertilizer)	5,743	2,089
Dealers	76,108	34,757
Other purposes	4,018	1,763
Total	414,622	$188,246

POTTERY.

	Value.
Red earthenware	$80,580 00
Miscellaneous	49,910 00
Total	$130,490 00

Plants cperating, 6.

PRODUCTION OF MINERAL WATER.

	Quantity. (Gallons.)	Value.
Medicinal use	1,560	$356
Table use	1,270,570	27,696
Other purposes	7,240	362
Total	1,801,652	$75,457

PRODUCTION OF TRAP ROCK.

	Quantity. (Tons.)	Value.
Crushed stone	22,000	$21,571
Concrete	34,000	29,429
Total	56,000	$51,000

CLAY PRODUCTION.

	Quantity. (Tons.)	Value.
Slip clay	1,744	$5,090
Fire clay	18	32
Brick clay	440	315
Total	2,202	$5,437

PRODUCTION OF GRINDSTONES.

	Value.
Total	$153,292

PRODUCTION OF SANDSTONE.

	Quantity. (Tons.)	Value.
Total	126,635	$12,985

PRODUCTION OF NATURAL GAS.

	Value.
Total	$1,005

MISCELLANEOUS.

	Value.
Miscellaneous products of Michigan, including mineral paints graphite, petroleum, oil stones, whet stones, sc thestones, coke, graphite and quartz	$1,502,630

TABLE SHOWING QUANTITY AND VALUE OF MINERALS AND MINERAL PRODUCTS IN MICHIGAN, 1911.

	Quantity.	Value.
Iron ore, tons	8,911,345	$23,802,210 00
*Copper, pounds	218,185,236	....
Coal, tons	1,476,074	2,791,461 00
Portland cement, barrels	3,686,716	3,024,676 00
†Salt, barrels	10,320,074	2,633,155 00
Brick and tile	....	1,633,401 00
Limestone, tons	1,835,197	952,471 00
Gypsum and gypsum products	....	573,926 00
Sand and gravel, tons	1,831,601	523,839 00
Sand lime brick	35,615,000	210,001 00
Lime, barrels	414,622	188,246 00
Pottery	....	130,490 00
Mineral water, gallons	1,801,652	75,457 00
Trap rock, tons	56,000	51,000 00
Clay, tons	2,202	5,437 00
Grindstones	....	153,292 00
Sandstone, tons	126,635	12,985 00
Natural gas	....	1,005 00
§Miscellaneous	....	1,502,630 00
¶Total	....	$38,165,682 00

* See pages 106-115 of this report.
† Value of bromine, calcium chloride, etc., $129,632.00.
§ Mineral paints, graphite, petroleum, oil stones, whet stones, scythe stones, coke, graphite and quartz.
¶ Value of copper, pig iron, glass sand, gems and precious stones is not included in this total.

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